WHOI-89-9

Surface Velocity in the Equatorial Oceans (20N–20S) Calculated from Historical Ship Drifts

by

Philip L. Richardson
Theresa K. McKee

Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

April 1989

Technical Report

Funding was provided by the National Science Foundation through grant Number OCE 87-16509.

Approved for Distribution:

Robert C Beardsley

Robert C. Beardsley, Chairman
Department of Physical Oceanography

Surface Velocity in the Equatorial Oceans (20N–20S) Calculated from Historical Ship Drifts

Philip L. Richardson

Theresa K. McKee

Woods Hole Oceanographic Institution

Woods Hole, Massachusetts 02543

March 22, 1989

Abstract

Ship drift velocity observations were used to calculate and plot monthly mean and yearly mean velocities in 2° latitude by 5° longitude boxes for the Atlantic, Pacific, and Indian Oceans. The vector maps shown here provide a visualization of the mean and seasonally varying currents.

1 Introduction

Historical ship drifts have provided most of the information about the near surface circulation of the ocean, but most maps of ship drift velocities are not suitable for visualizing the strong seasonal variability of equatorial currents. In order to obtain maps of the seasonal variations we calculated and plotted monthly mean velocity on a 2° latitude by 5° longitude grid for the band 20S to 20N. We thought that other people might find these maps useful in their studies, and so we show them here. The data in the Atlantic was studied statistically as described by Richardson and Walsh (1986).

2 Data

The historical ship drifts were obtained from NODC. Each ship drift measurement of surface velocity is the vector difference between the velocity of a ship between two position fixes and the dead reckoning velocity of the ship through the water during the same time interval, normally 12–24 hours. The vector difference is considered to be due to a surface current. Many possible random and systematic errors can occur as discussed by Stidd (1975), Richardson (1983) and Richardson and Walsh (1986).

The historical ship drift observations were made from 1854 to 1974, but most were obtained between 1920–1941. During 1920–1934, some large areas are devoid of observations in some months (Richardson, 1989). The observations are concentrated along major shipping routes where the number of observations is greater than approximately 1000 per 2° x 5° box. The equatorial Atlantic and Indian Oceans have a good coverage of ship routes and data; most areas have 500–5000 observations per box. The Pacific has relatively fewer observations; most

boxes contain 100–500 observations. The monthly average velocity vectors in the Pacific have more scatter due to the lower data density there.

3 Maps

For each ocean, maps were made showing (1) the total number of observations in each 2° x 5° box, (2) the annual mean velocity vectors, and (3) the monthly mean velocity vectors. The Atlantic is shown first, then the Indian, and last the Pacific. In addition, seasonal maps were made on a 1° x 1° grid showing velocity in the Indonesian Seas and western tropical Pacific. Figure captions are given below.

4 List of Figure Captions

Figure 1: Geographical distribution of the number of ship drift velocity observations in 2° latitude by 5° longitude boxes in the equatorial Atlantic. These numbers of observations correspond to the map of the annual mean velocity. Maps of the monthly mean velocity used roughly 1/12 of the number of measurements shown here.

Figure 2: Map of the annual mean surface velocity of the equatorial Atlantic.

Figures 3–14: Maps of the monthly mean surface velocity of the equatorial Atlantic.

Figure 15: Geographical distribution of observations in the Indian Ocean.

Figure 16: Map of the annual mean surface velocity of the equatorial Indian Ocean.

Figures 17–28: Maps of the monthly mean surface velocity of the equatorial Indian Ocean.

Figure 29: Geographic distribution of observations in the Pacific Ocean.

Figure 30: Map of the annual mean surface velocity of the equatorial Pacific Ocean.

Figures 31–42: Maps of the monthly mean surface velocity of the equatorial Pacific Ocean.

Figures 43–44: Maps of the mean surface velocity in the western Pacific and Indonesian Seas for summer (May–October) and winter (November–April). Vectors in boxes containing more than 20 observations have solid black arrowheads.

Figures 45–46: Maps of the mean surface velocity in the western Pacific and Indonesian Seas for summer (May–October) and winter (November–April). Velocity vectors from Figs. 43–44 were smoothed somewhat to emphasize the dominant circulation features.

Acknowledgements

Funds were provided by the National Science Foundation (Grant OCE87-16509). George Heimerdinger helped obtain the data from NODC, and Mary Ann Lucas typed the manuscript.

References

Richardson, P. L., 1983. Eddy kinetic energy in the North Atlantic from surface drifters. *Journal of Geophysical Research*, **88**, 4355–4367.

Richardson, P. L., 1989. Worldwide ship drift distributions identify missing data. *Journal of Geophysical Research*, in press.

Richardson, P. L. and D. Walsh, 1986. Mapping climatological seasonal variations of surface currents in the tropical Atlantic using ship drifts. *Journal of Geophysical Research*, **91**, 10,537–10,550.

Stidd, C. K., 1975. Meridional profiles of ship drift components. *Journal of Geophysical Research*, **80**, 1679–1682.

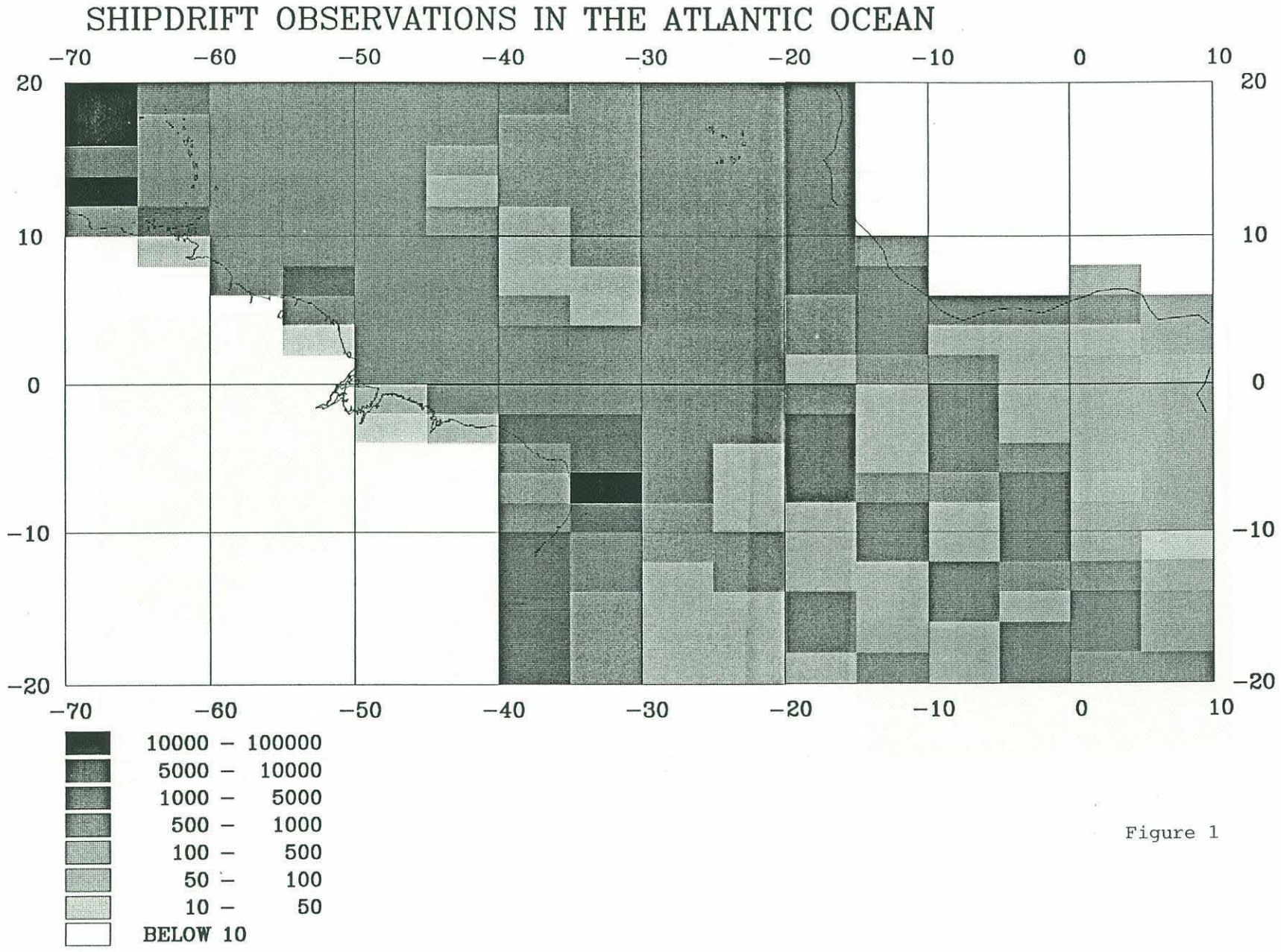
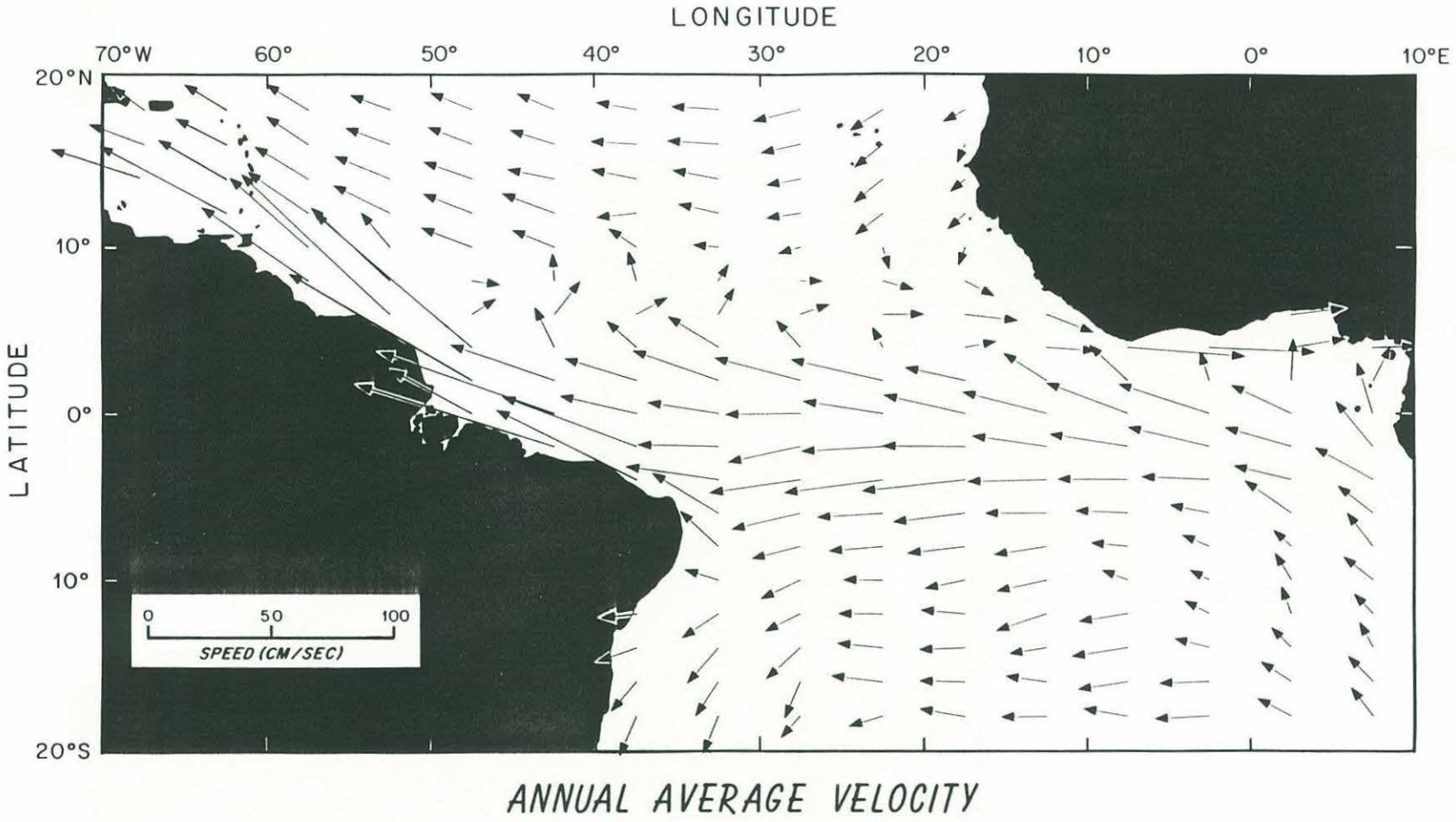

SHIPDRIFT OBSERVATIONS IN THE ATLANTIC OCEAN
-70
-60
-50
-40
-30
-20
-10
0
10
20
10
0
-10
-20
10000 - 100000
5000 - 10000
1000 - 5000
500 - 1000
100 - 500
50 - 100
10 - 50
BELOW 10

Figure 1



ANNUAL AVERAGE VELOCITY

Figure 2

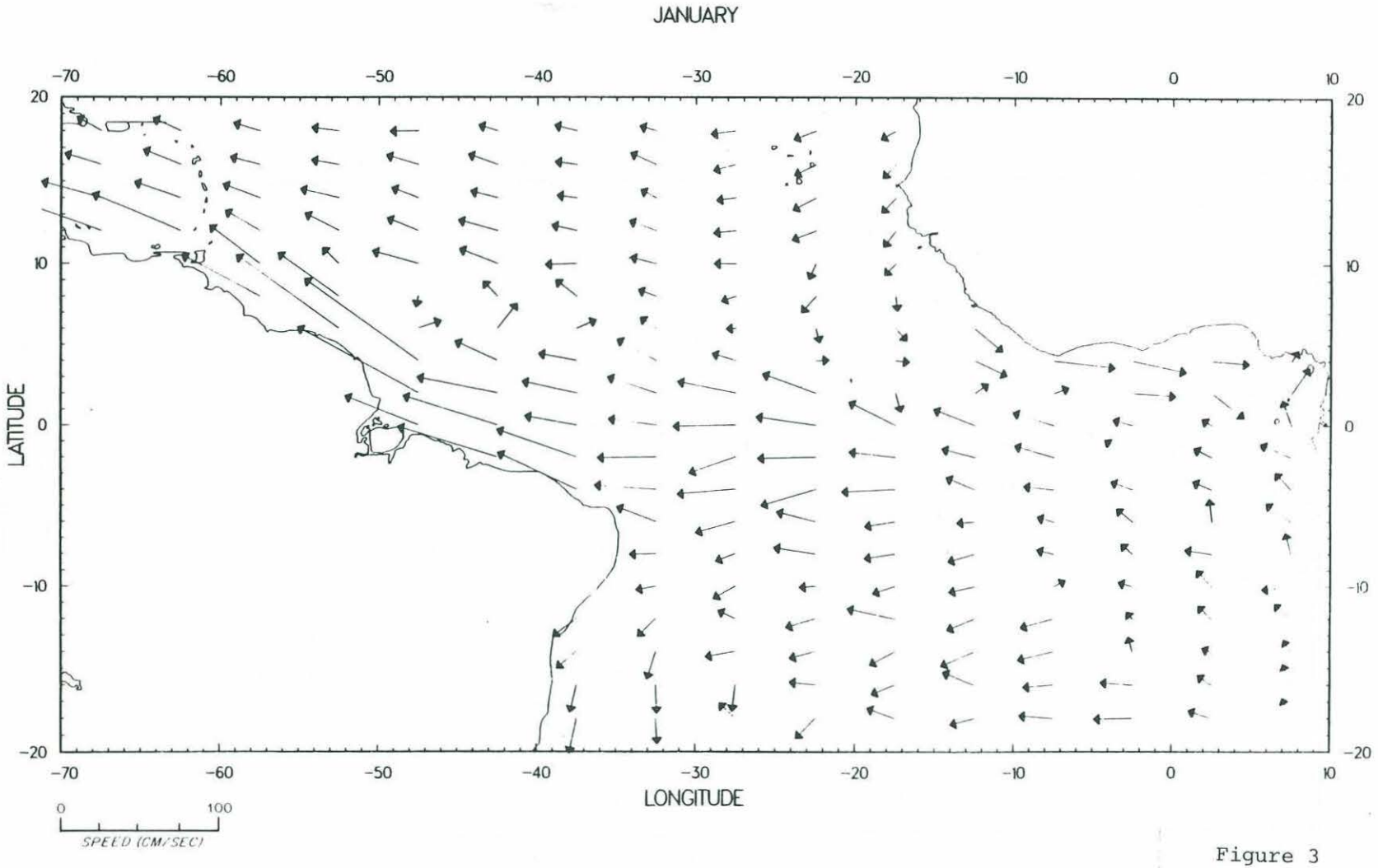

JANUARY
LATITUDE
LONGITUDE
-70
-60
-50
-40
-30
-20
-10
0
10
20
-20
0
100
SPEED (CM/SEC)

Figure 3

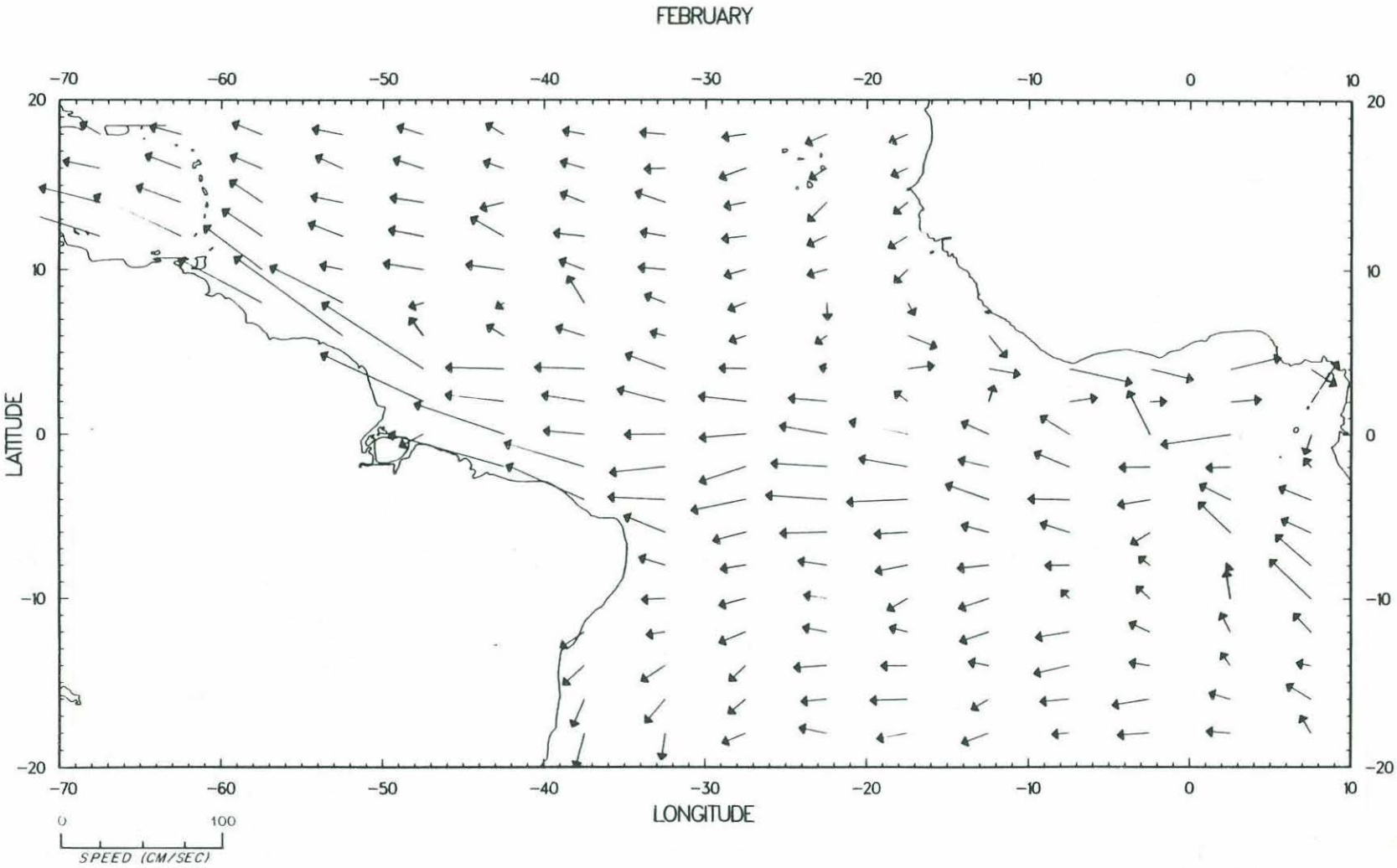

FEBRUARY
-70
-60
-50
-40
-30
-20
-10
0
10
20
LATITUDE
LONGITUDE
0
100
SPEED (CM/SEC)

Figure 4

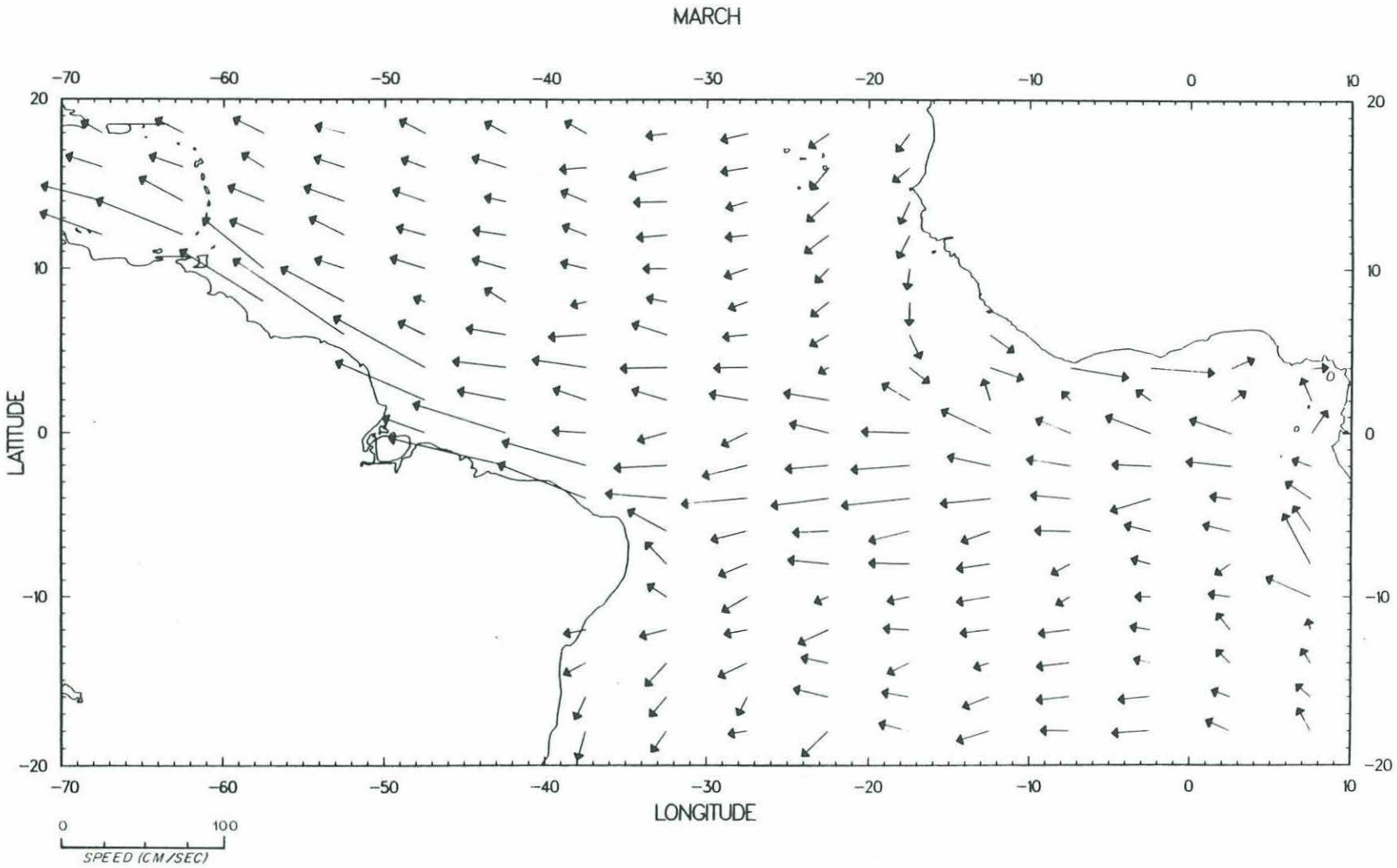

MARCH
-70
-60
-50
-40
-30
-20
-10
0
10
20
LATITUDE
LONGITUDE
0
100
SPEED (CM/SEC)

Figure 5

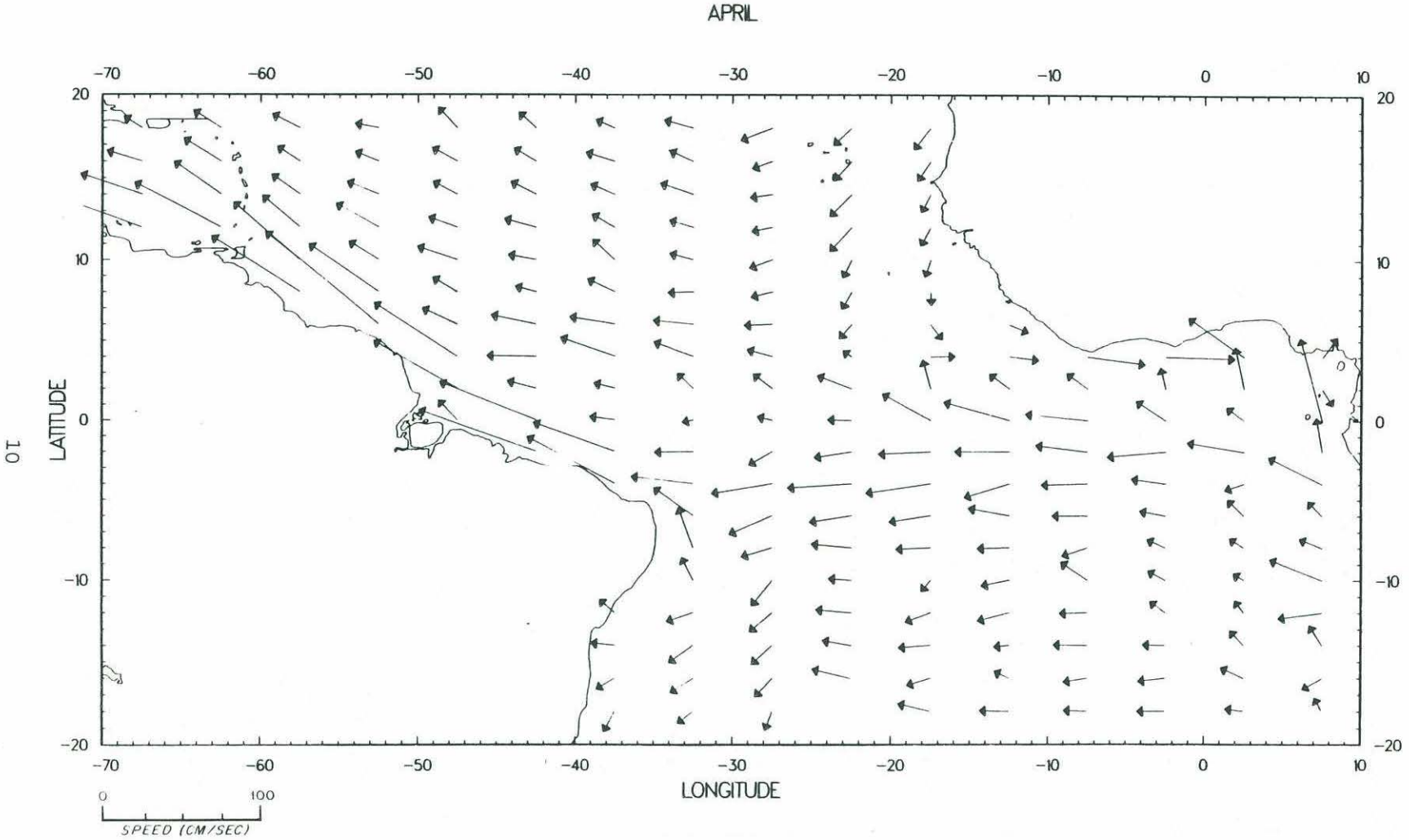

APRIL
-70
-60
-50
-40
-30
-20
-10
0
10
20
LATITUDE
LONGITUDE
0
100
SPEED (CM/SEC)

Figure 6

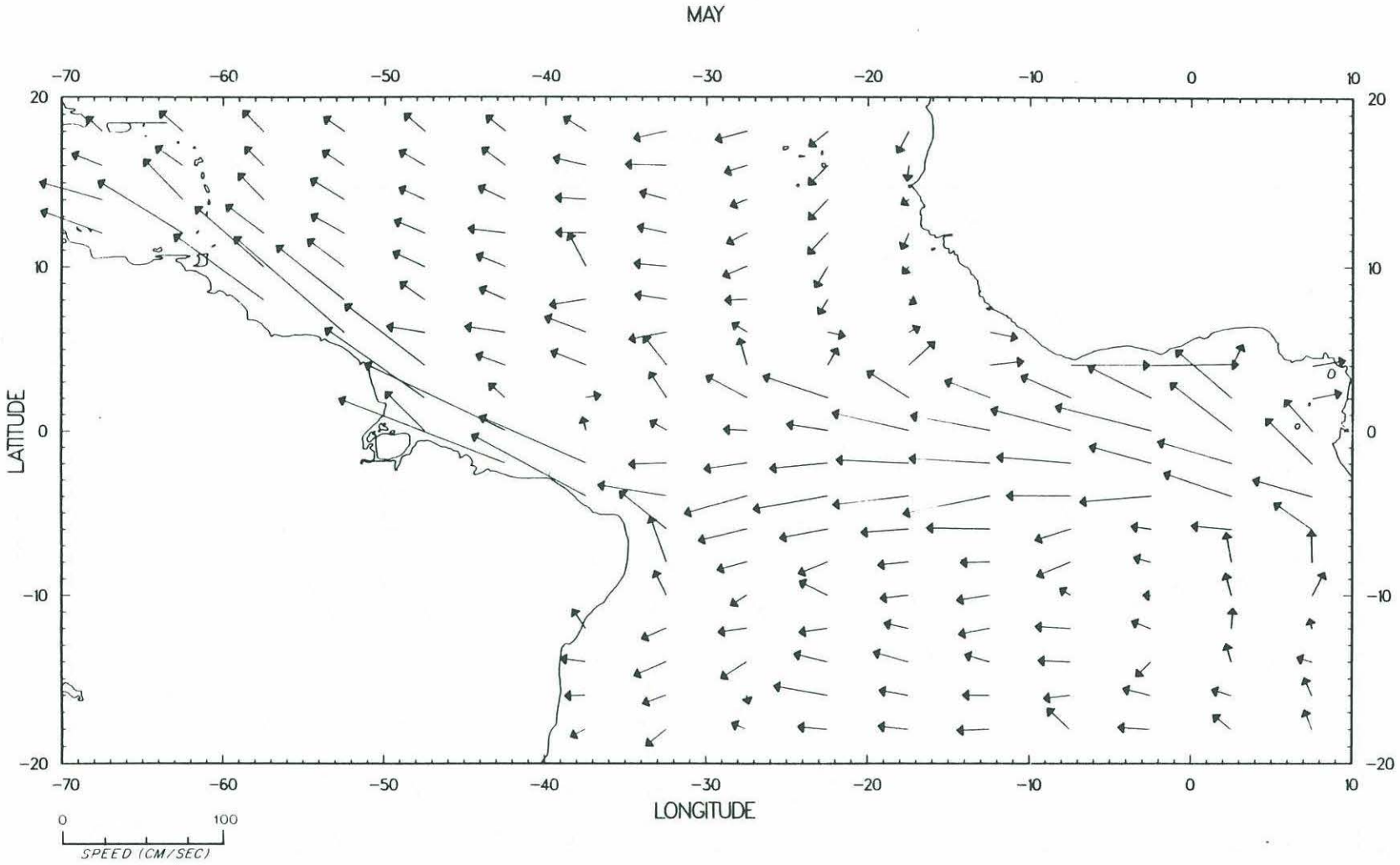

MAY
-70
-60
-50
-40
-30
-20
-10
0
10
20
10
0
-10
-20
LATITUDE
LONGITUDE
0
100
SPEED (CM/SEC)

Figure 7

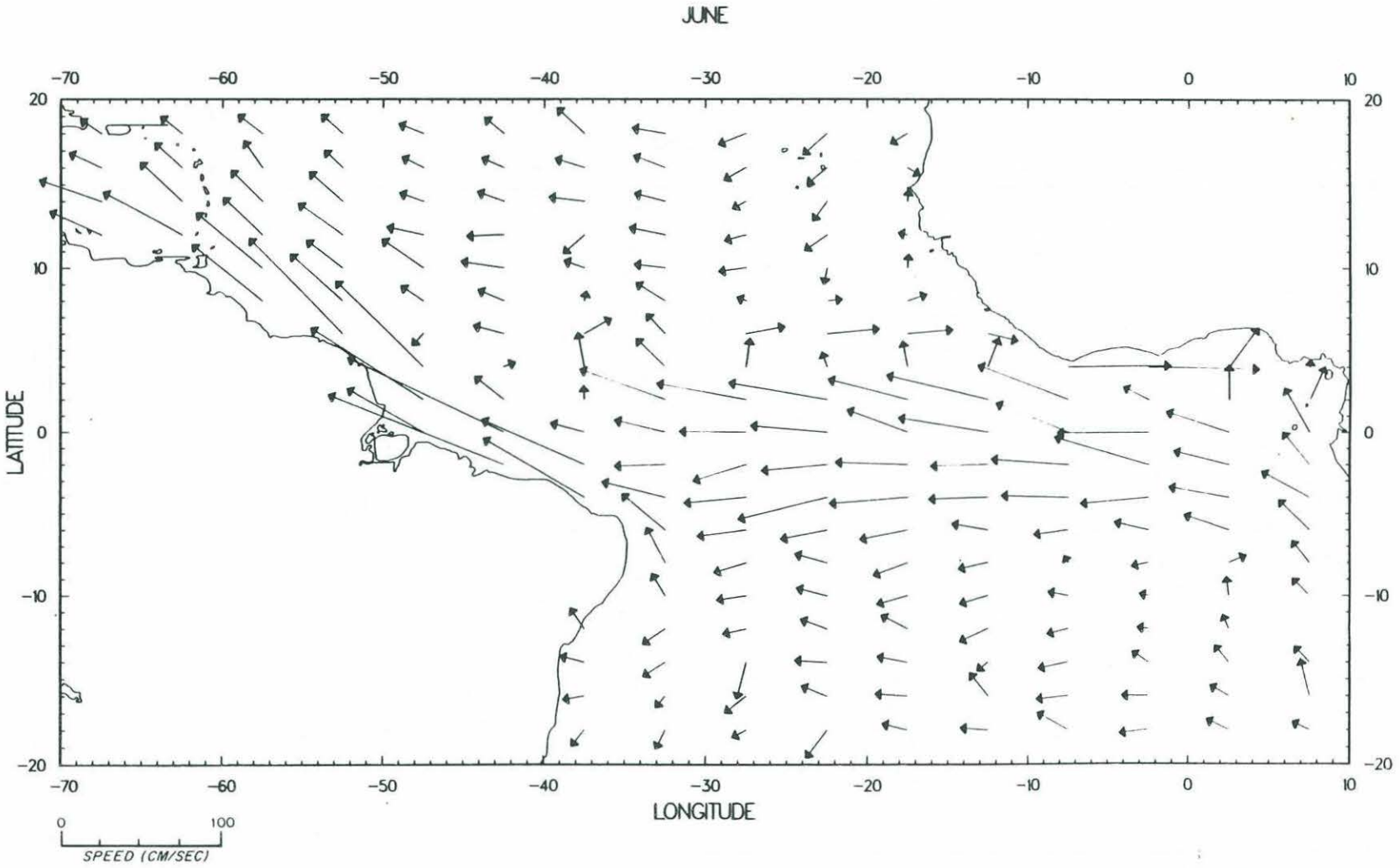

JUNE
-70
-60
-50
-40
-30
-20
-10
0
10
20
LATITUDE
LONGITUDE
0
100
SPEED (CM/SEC)

Figure 8

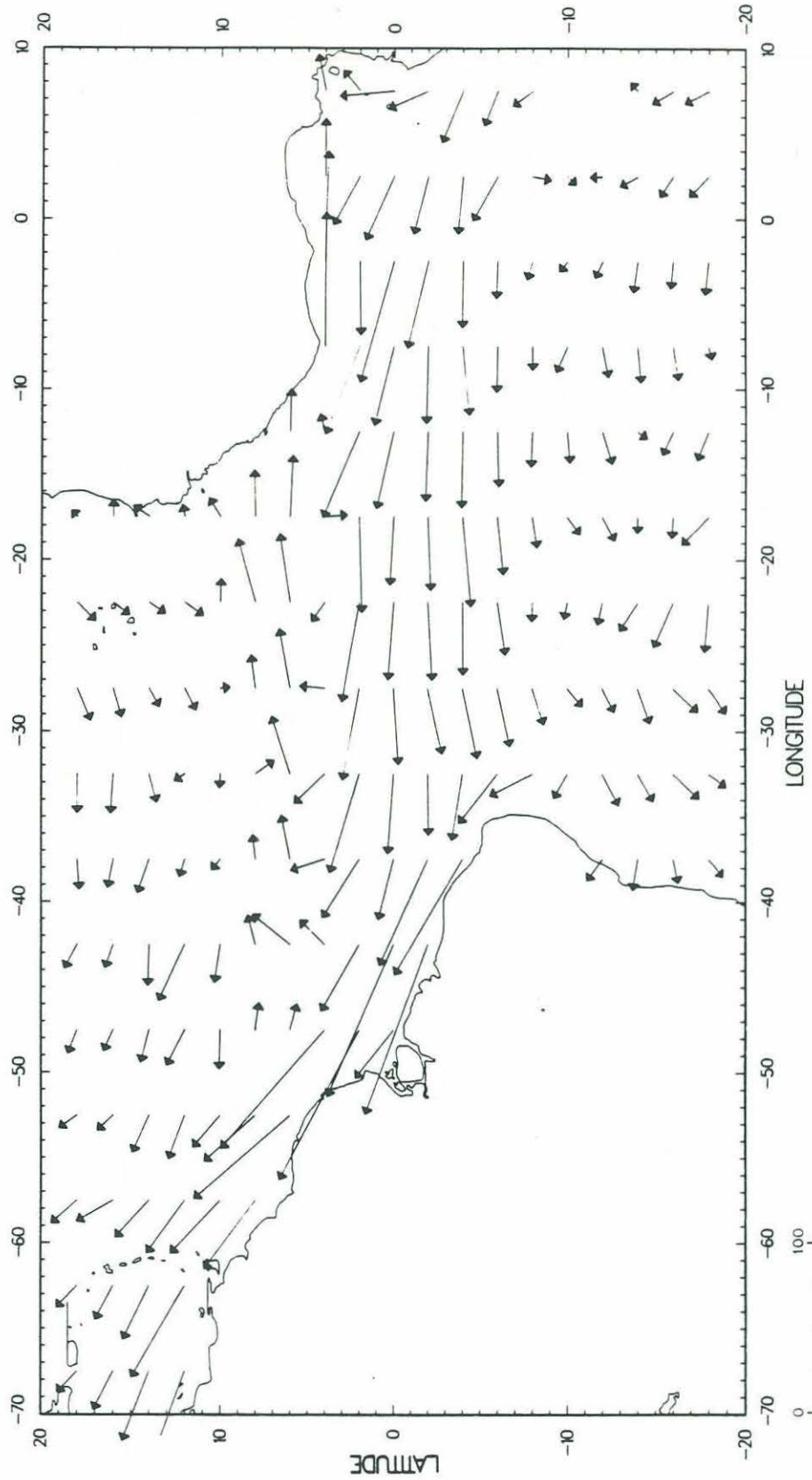


Figure 9

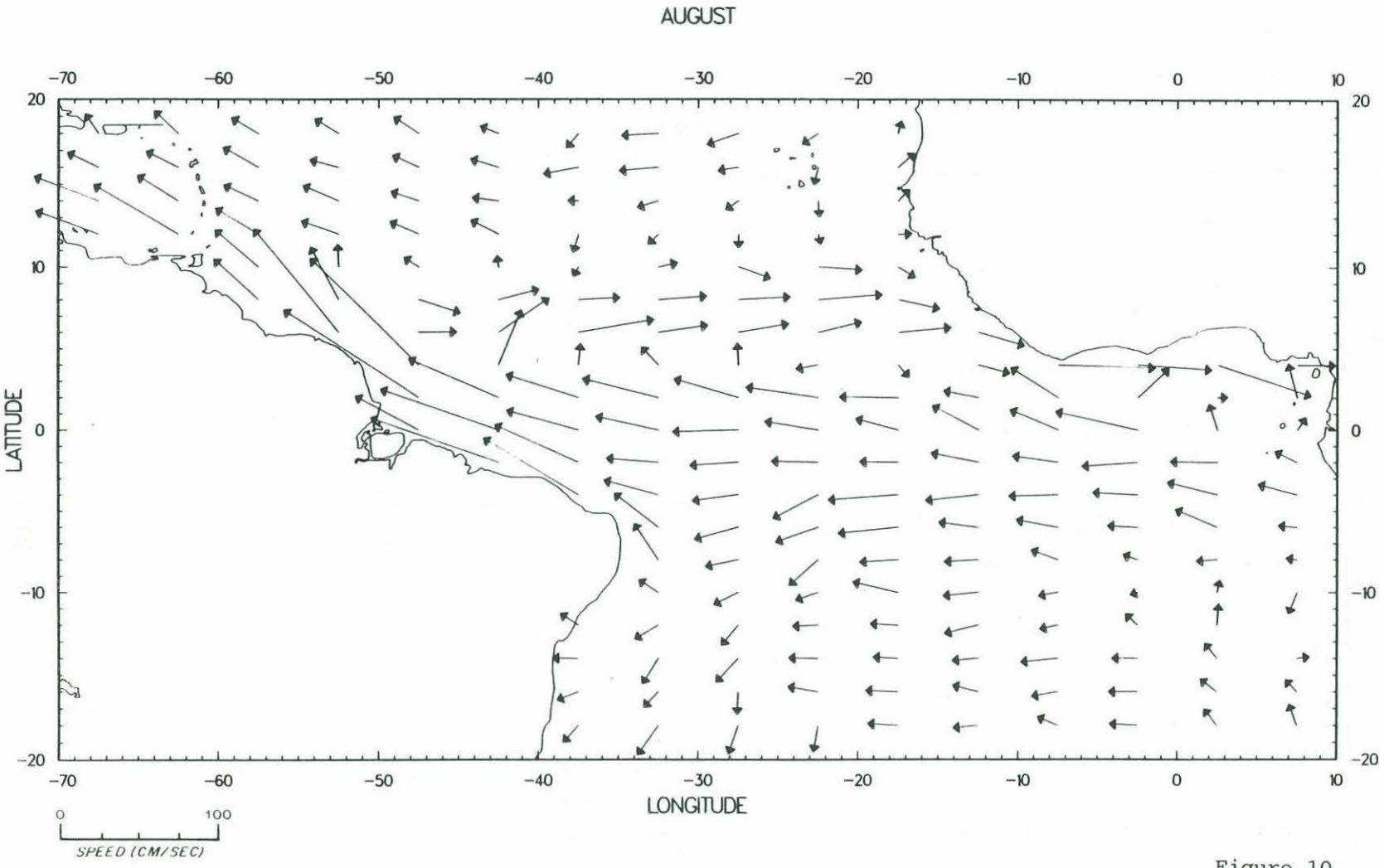

AUGUST
-70
-60
-50
-40
-30
-20
-10
0
10
20
LATITUDE
LONGITUDE
0
100
SPEED (CM/SEC)

Figure 10

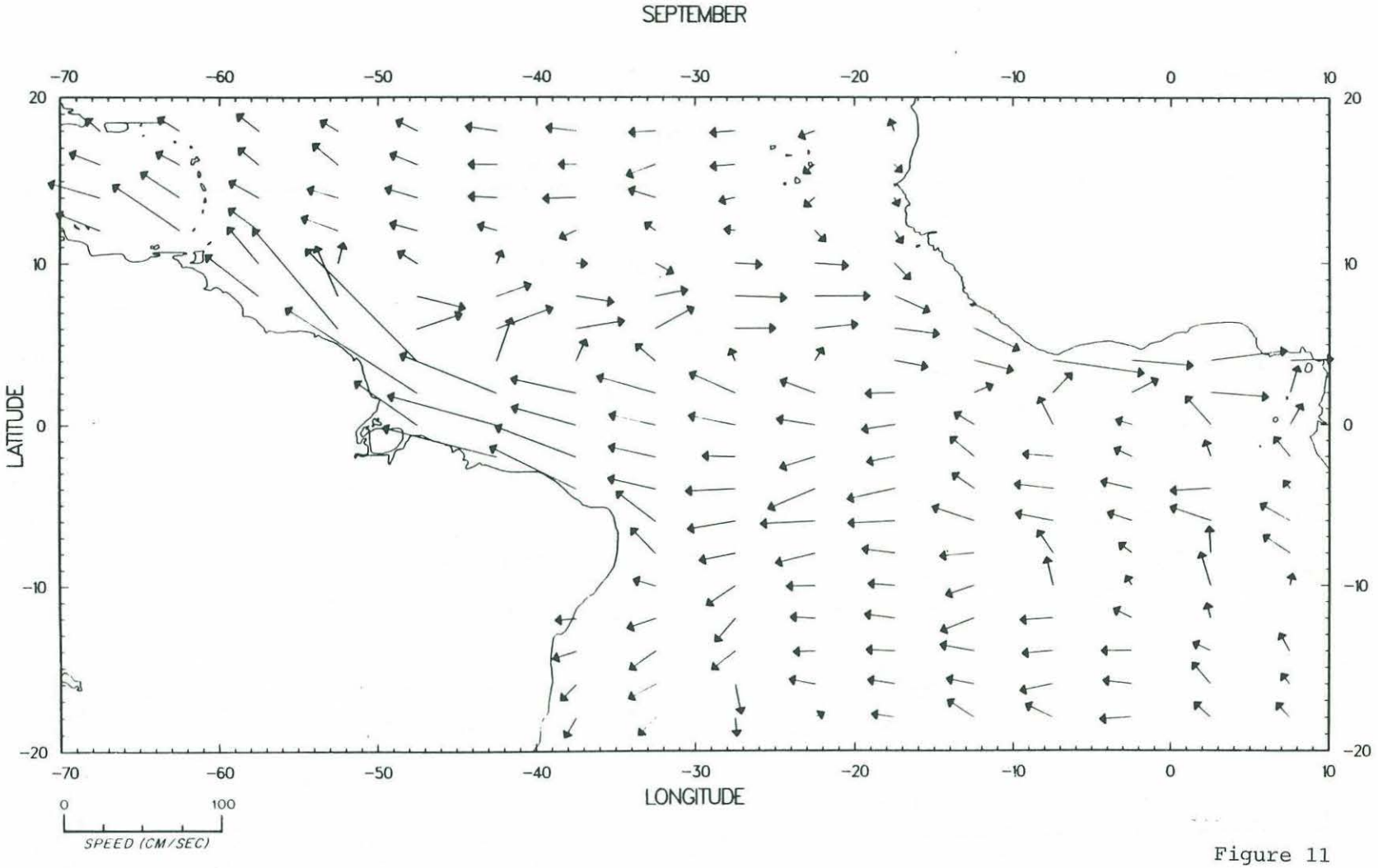

SEPTEMBER
LATITUDE
LONGITUDE
-70
-60
-50
-40
-30
-20
-10
0
10
20
0
100
SPEED (CM/SEC)

Figure 11

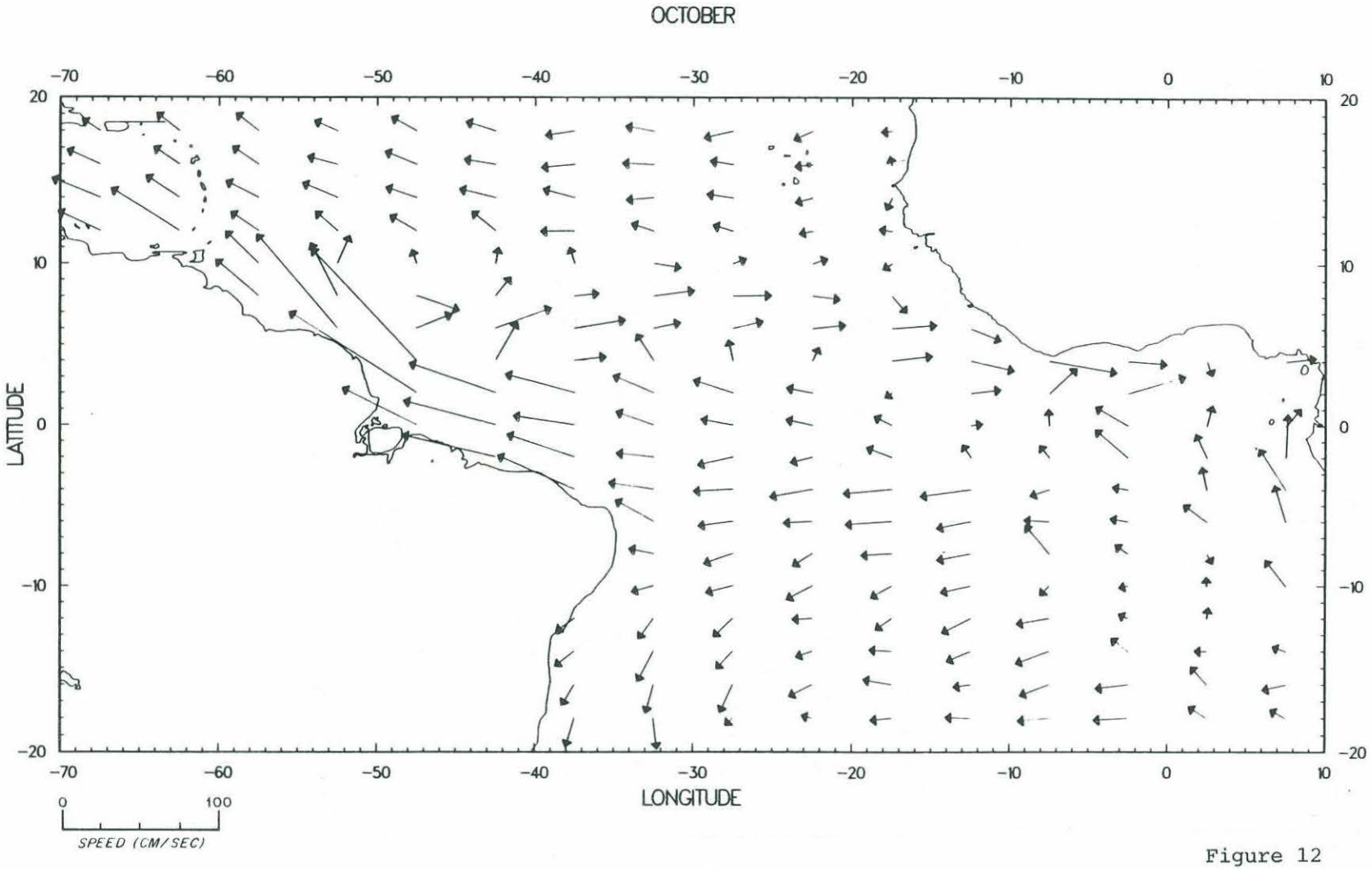

OCTOBER
-70
-60
-50
-40
-30
-20
-10
0
10
20
LATITUDE
LONGITUDE
0
100
SPEED (CM/SEC)

Figure 12

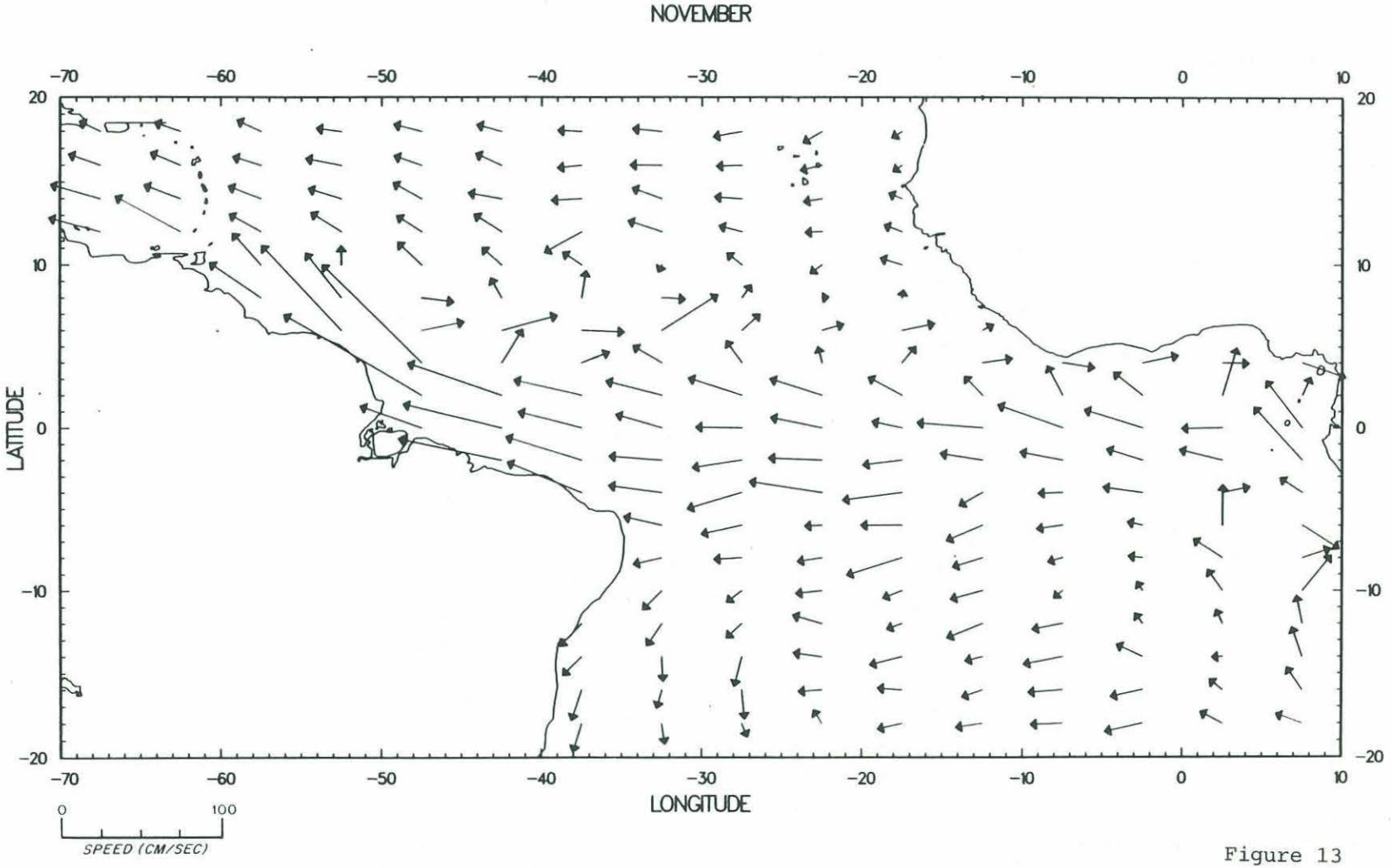

NOVEMBER
LATITUDE
LONGITUDE
-70
-60
-50
-40
-30
-20
-10
0
10
20
0
100
SPEED (CM/SEC)

Figure 13

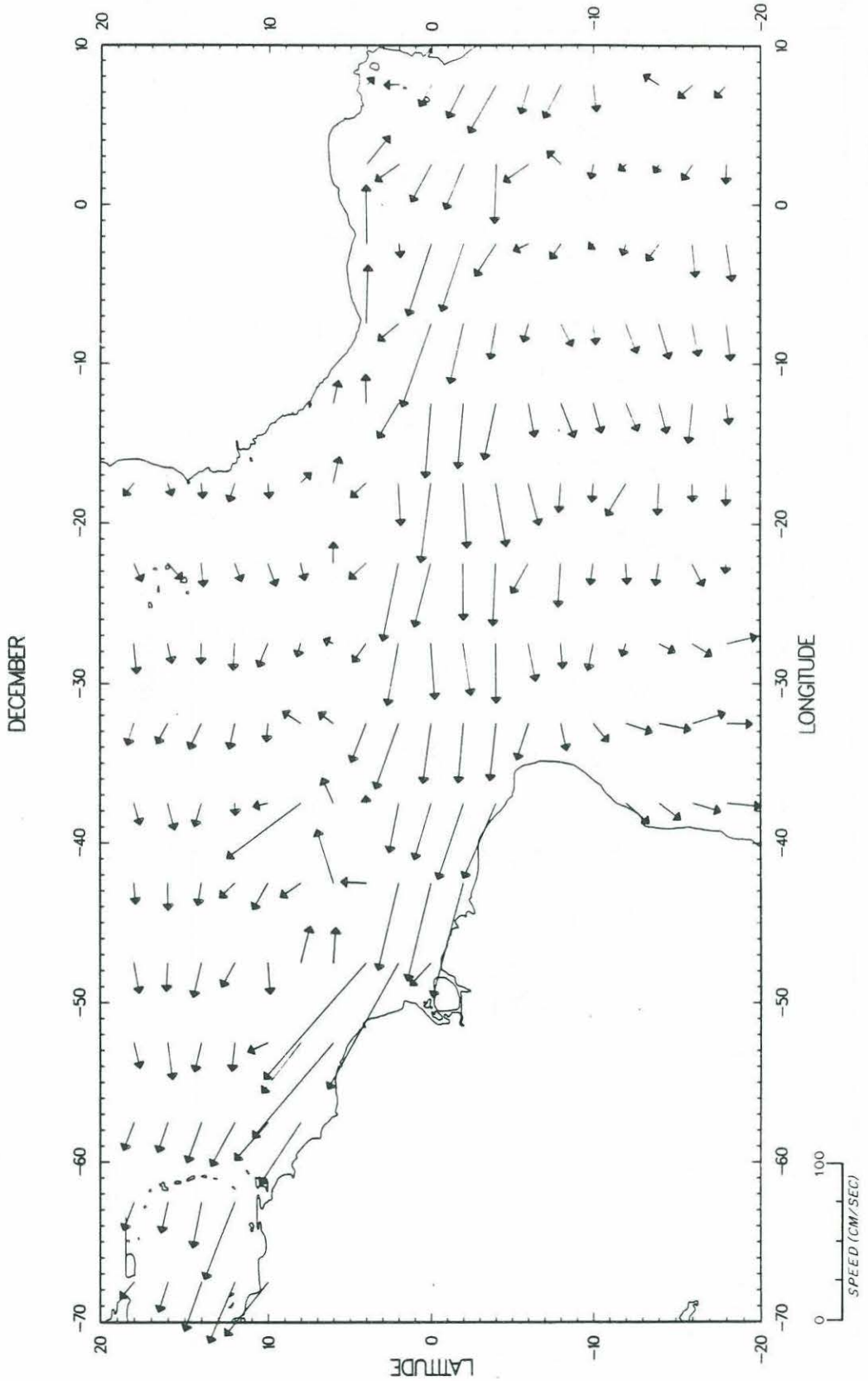


Figure 14

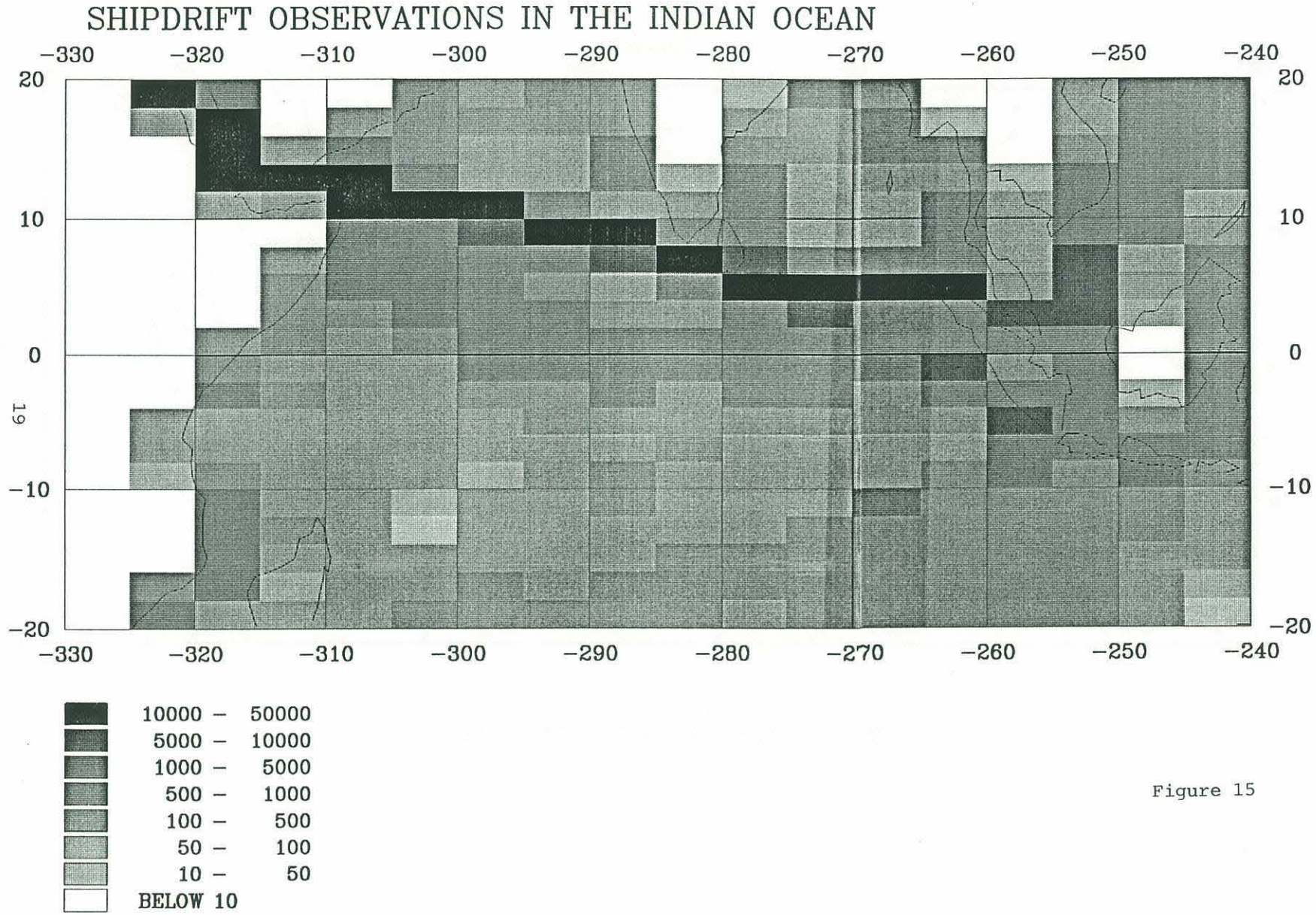

SHIPDRIFT OBSERVATIONS IN THE INDIAN OCEAN
-330
-320
-310
-300
-290
-280
-270
-260
-250
-240
20
10
0
-10
-20
10000 - 50000
5000 - 10000
1000 - 5000
500 - 1000
100 - 500
50 - 100
10 - 50
BELOW 10

Figure 15

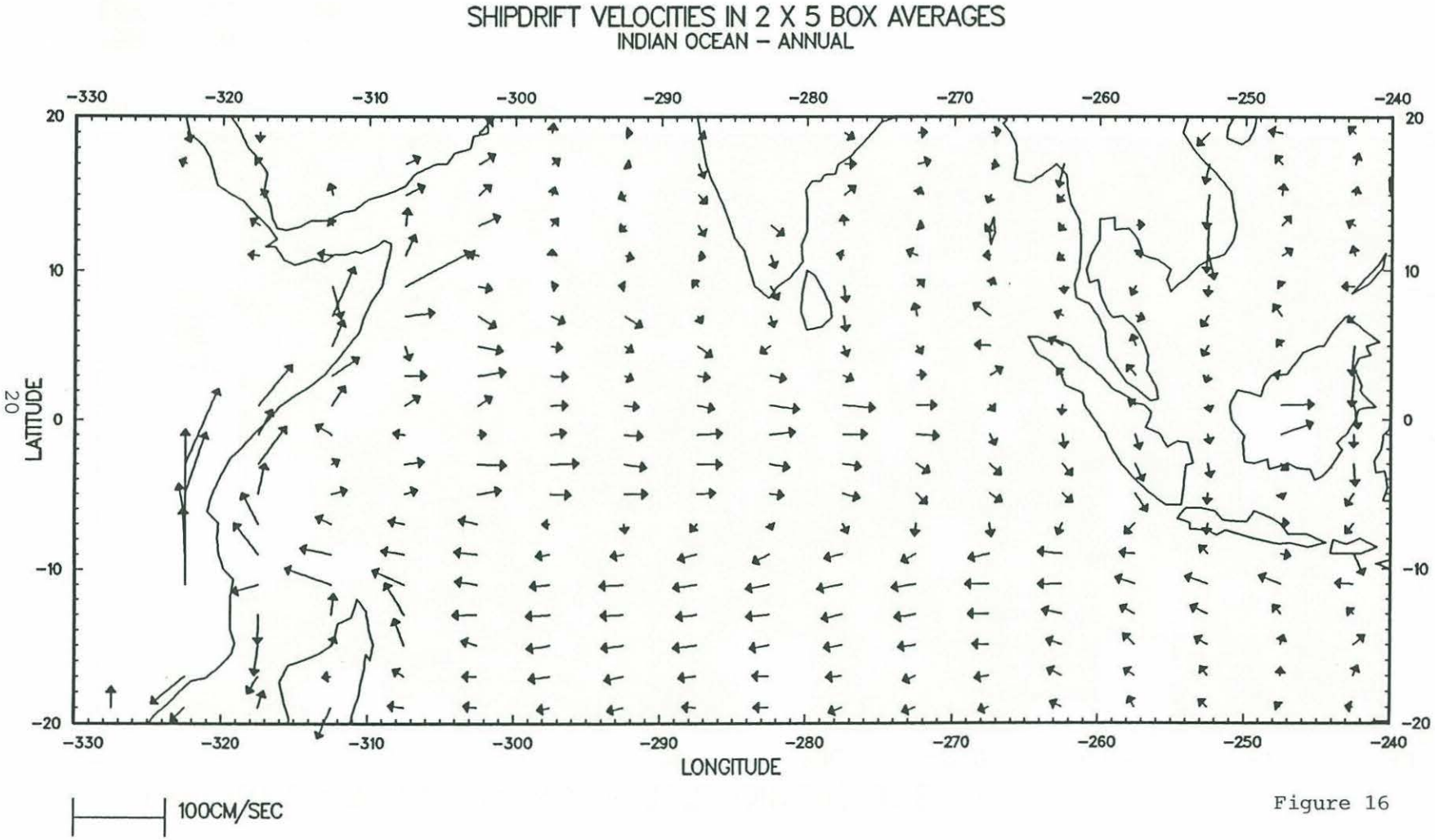

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
INDIAN OCEAN – ANNUAL
-330
-320
-310
-300
-290
-280
-270
-260
-250
-240
20
10
0
-10
-20
LATITUDE
LONGITUDE
100CM/SEC

Figure 16

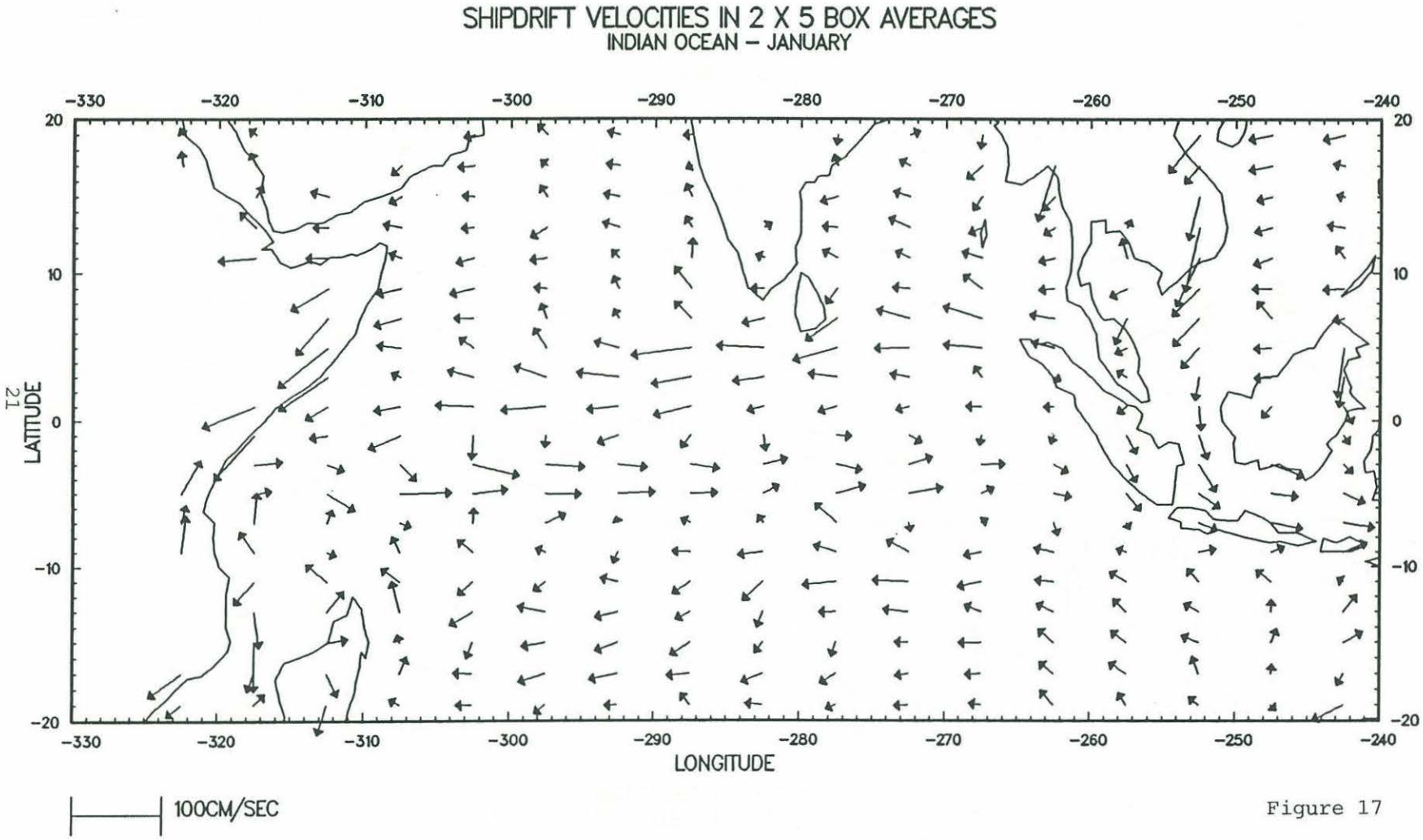

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
INDIAN OCEAN – JANUARY
-330
-320
-310
-300
-290
-280
-270
-260
-250
-240
20
10
0
-10
-20
LATITUDE
LONGITUDE
100CM/SEC

Figure 17

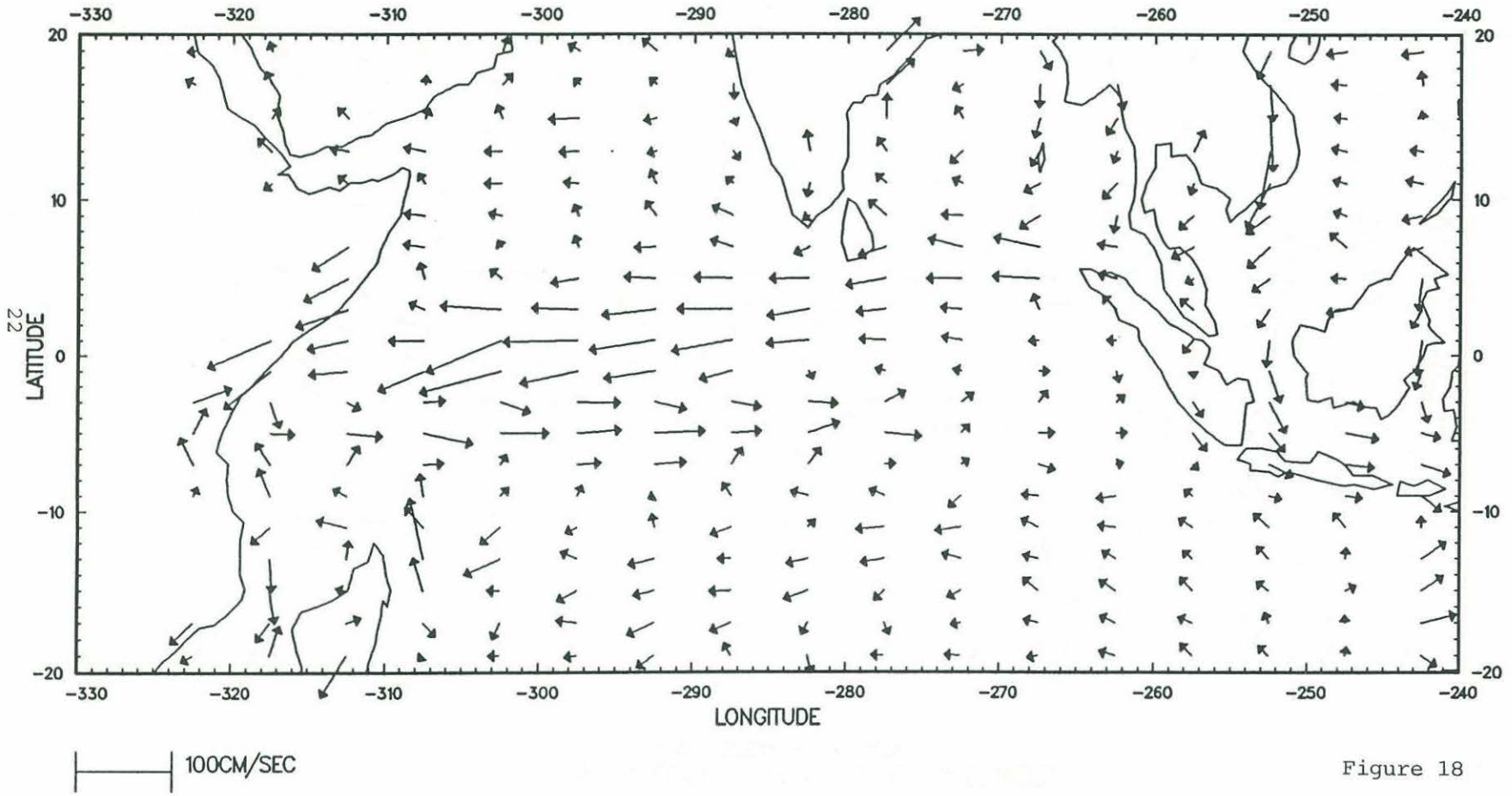

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
INDIAN OCEAN – FEBRUARY
-330
-320
-310
-300
-290
-280
-270
-260
-250
-240
20
10
0
-10
-20
LATITUDE
LONGITUDE
100CM/SEC

Figure 18

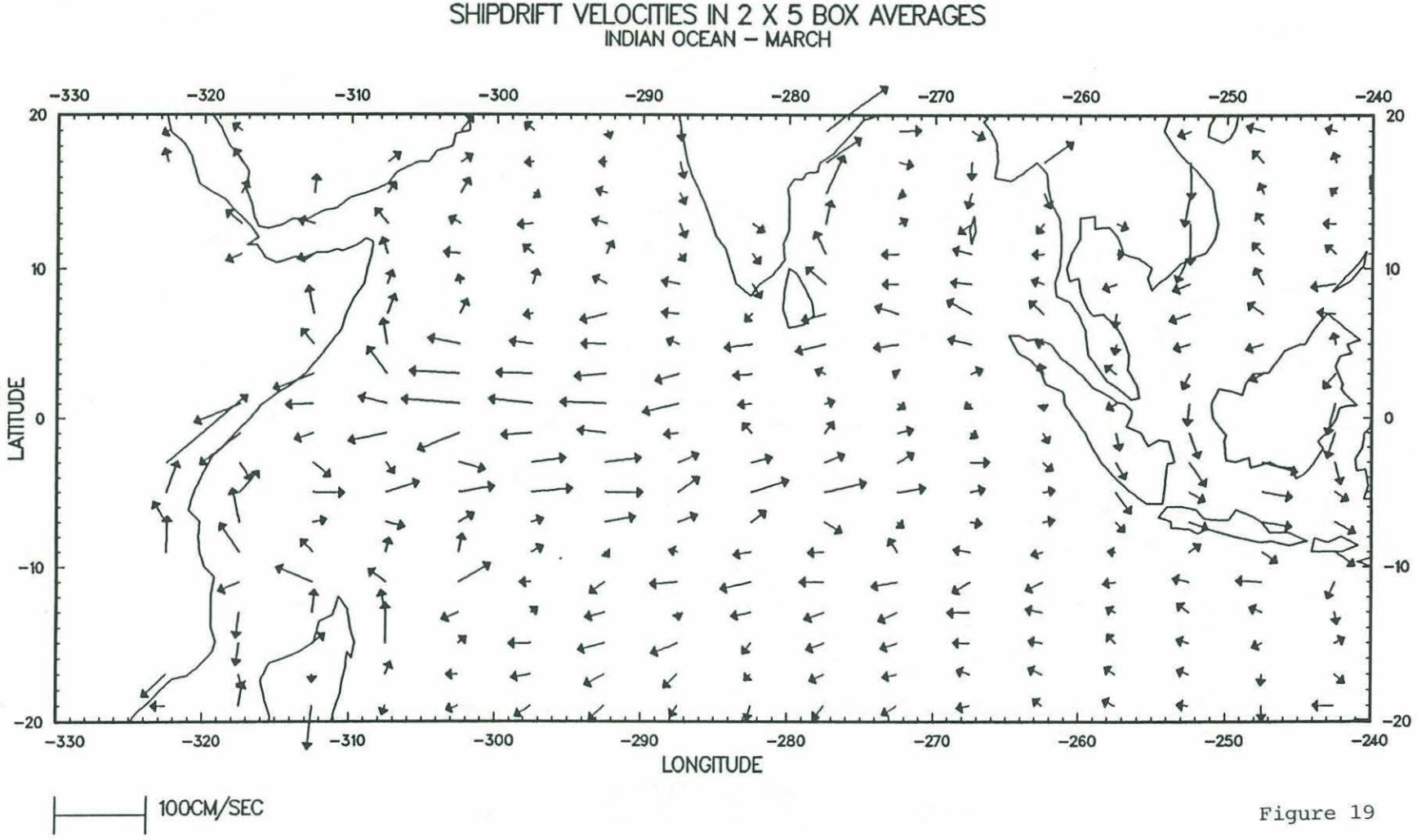

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
INDIAN OCEAN – MARCH
-330
-320
-310
-300
-290
-280
-270
-260
-250
-240
20
10
0
-10
-20
LATITUDE
LONGITUDE
100CM/SEC

Figure 19

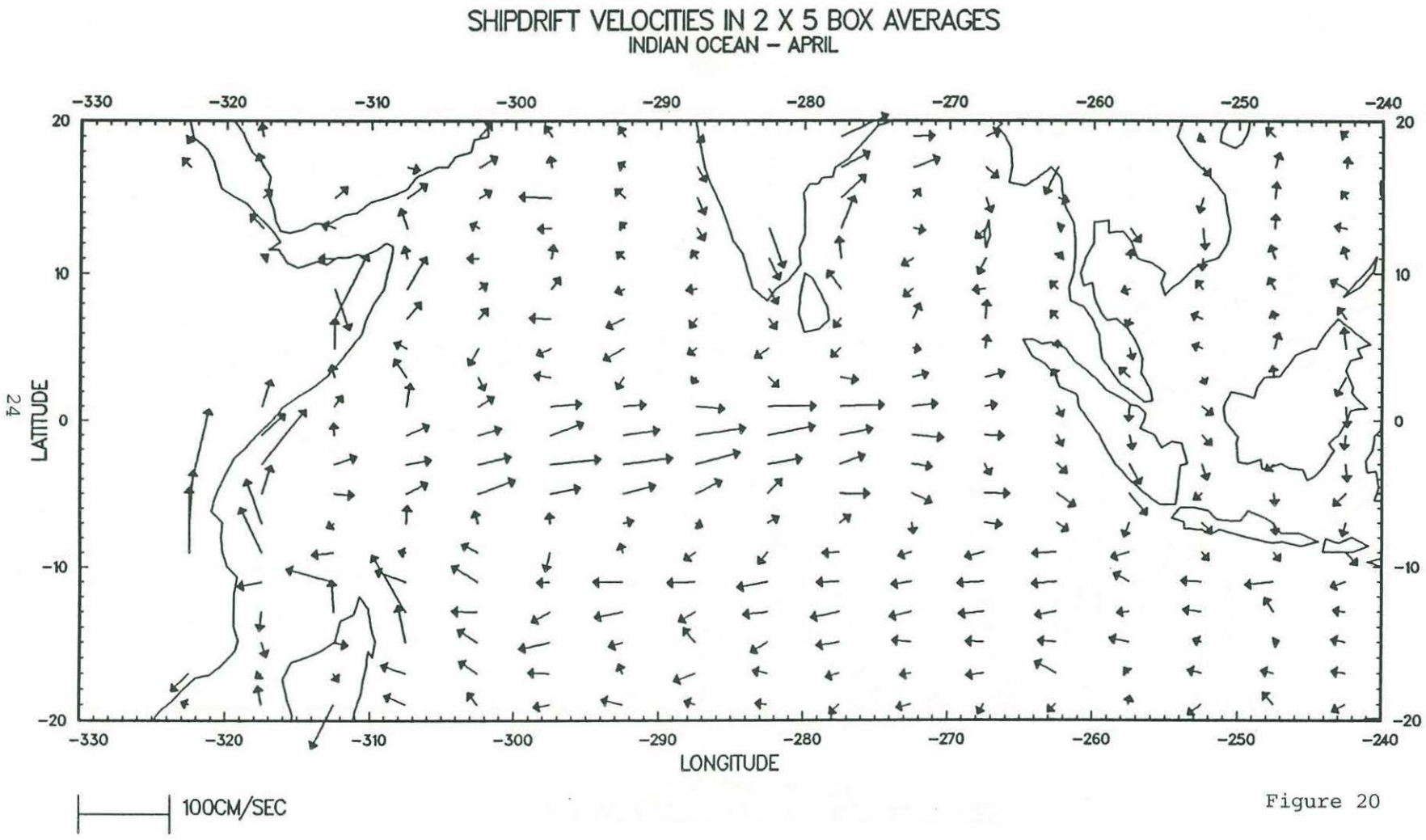

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
INDIAN OCEAN – APRIL
-330
-320
-310
-300
-290
-280
-270
-260
-250
-240
20
10
0
-10
-20
LATITUDE
LONGITUDE
100CM/SEC

Figure 20

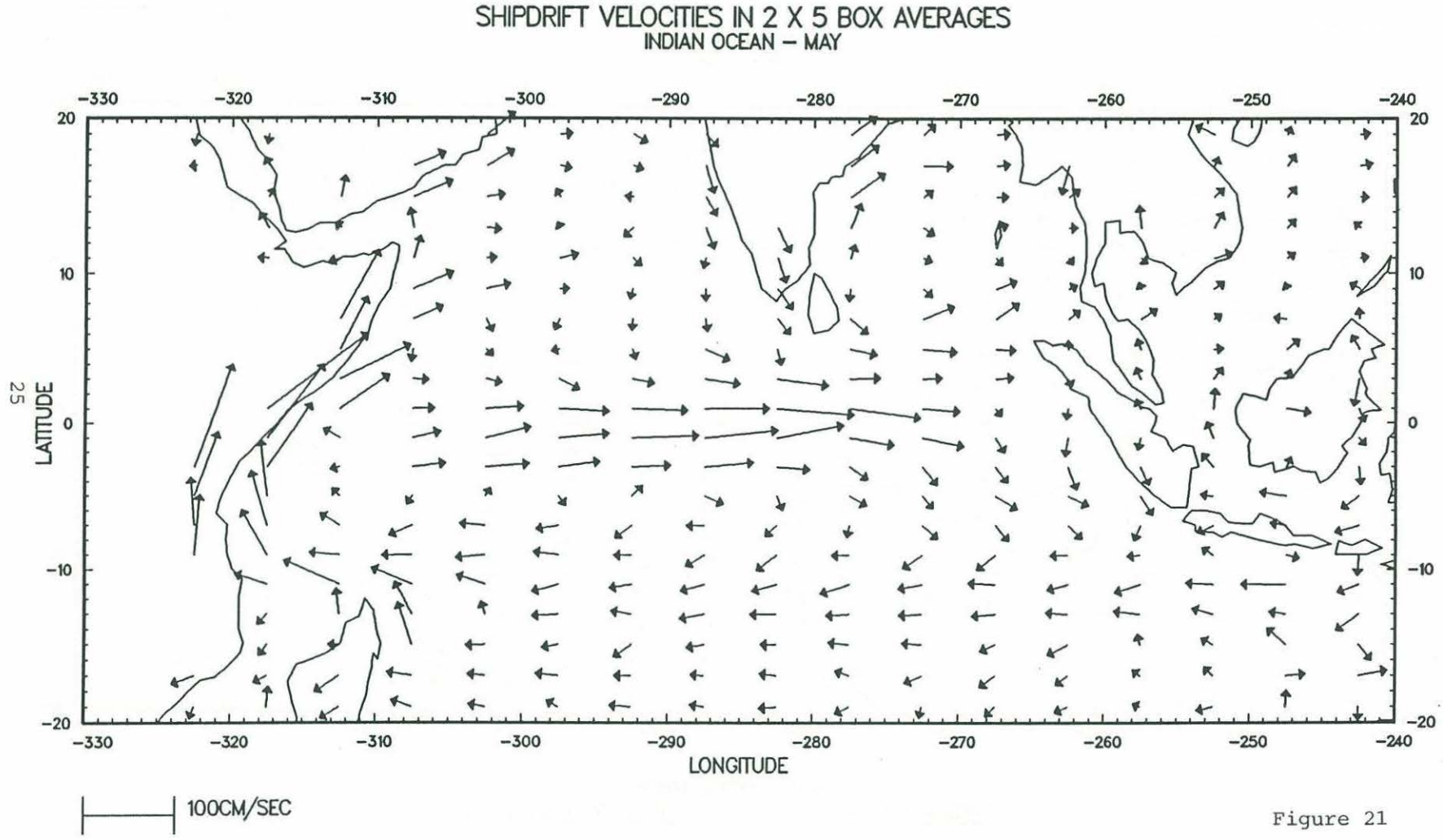

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
INDIAN OCEAN – MAY
-330
-320
-310
-300
-290
-280
-270
-260
-250
-240
20
10
0
-10
-20
LATITUDE
LONGITUDE
100CM/SEC

Figure 21

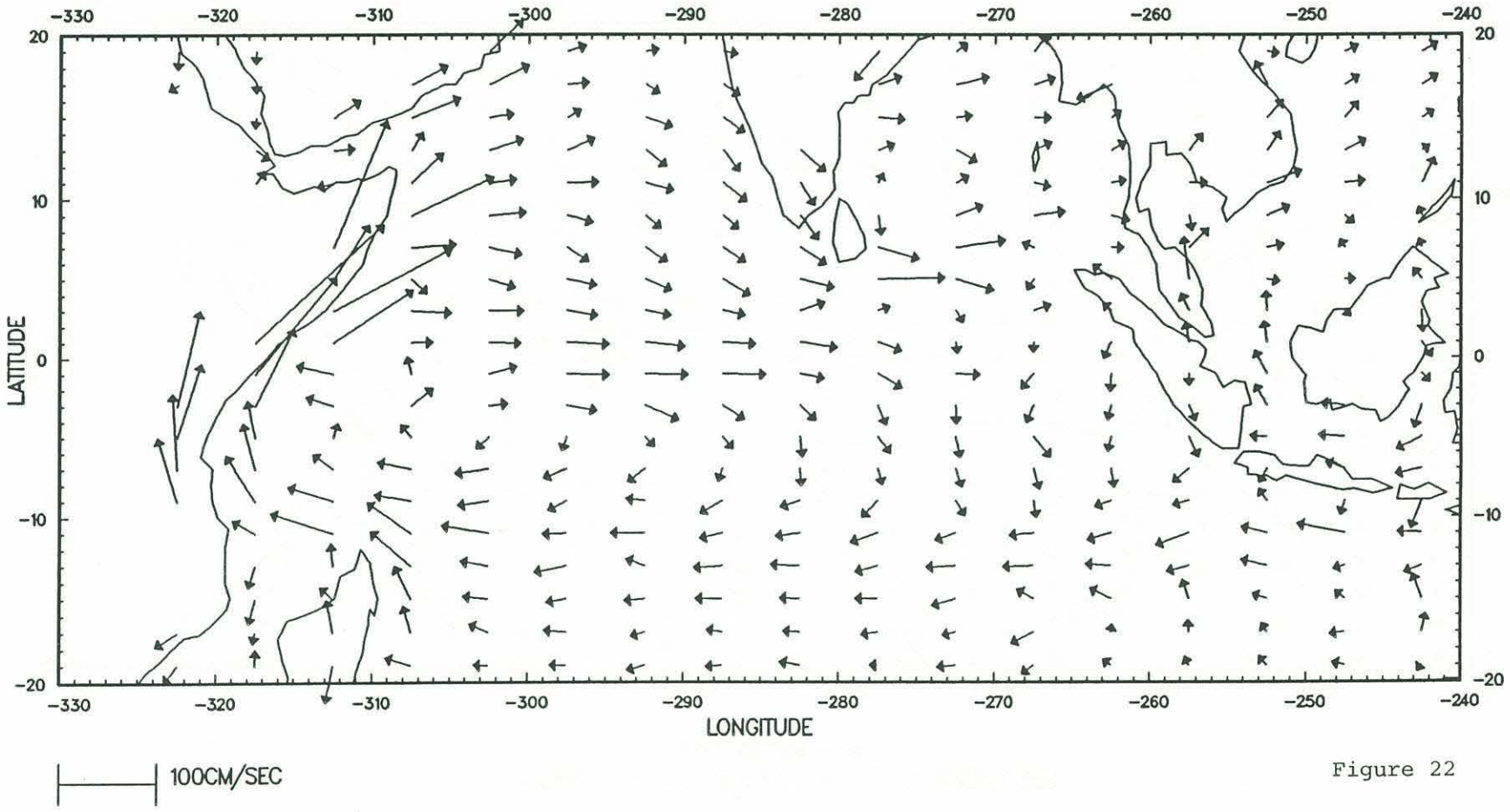

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
INDIAN OCEAN – JUNE
-330
-320
-310
-300
-290
-280
-270
-260
-250
-240
20
10
0
-10
-20
LATITUDE
LONGITUDE
100CM/SEC

Figure 22

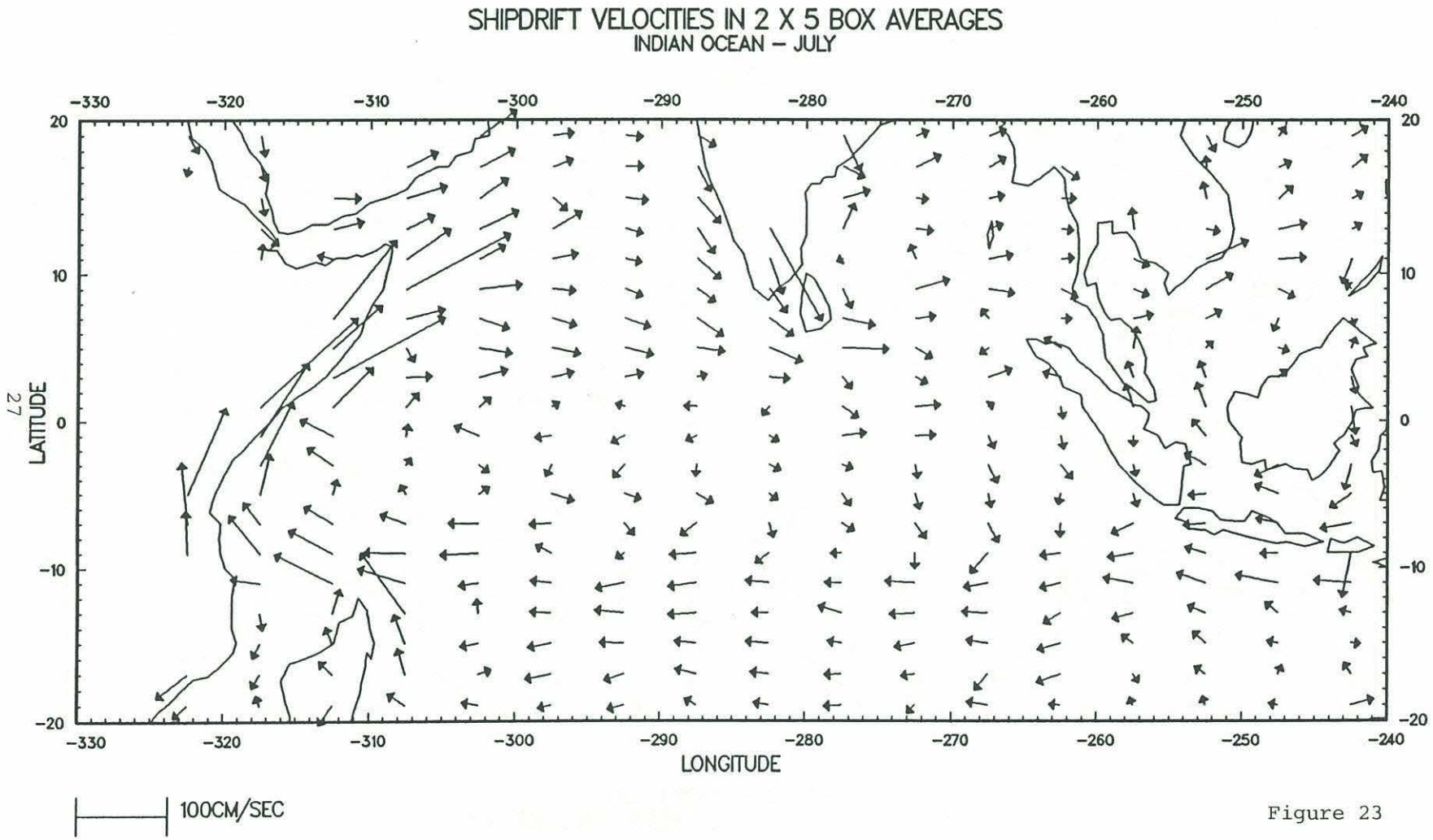

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
INDIAN OCEAN – JULY
-330
-320
-310
-300
-290
-280
-270
-260
-250
-240
20
10
0
-10
-20
LATITUDE
LONGITUDE
100CM/SEC

Figure 23

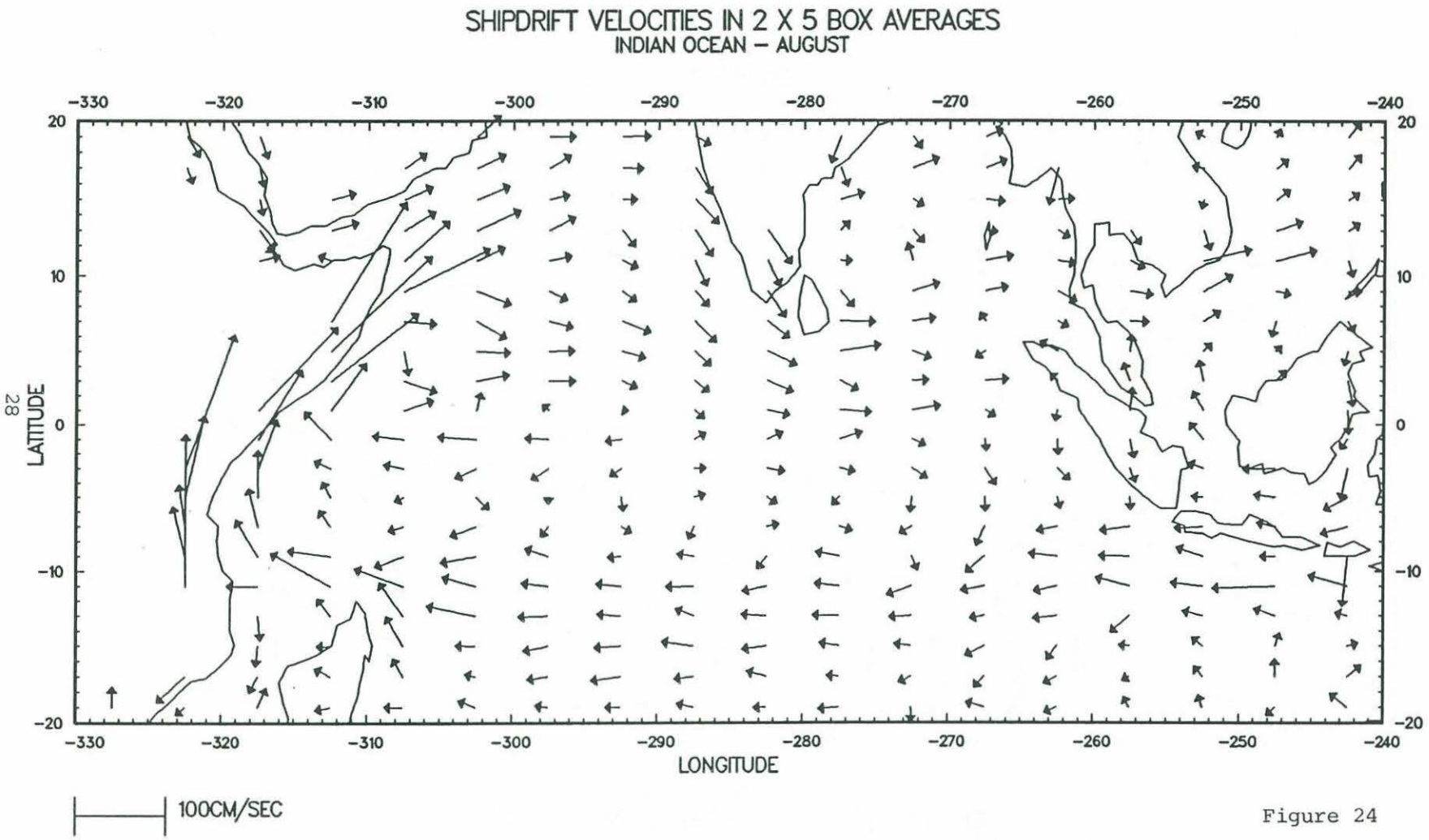

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
INDIAN OCEAN – AUGUST
-330
-320
-310
-300
-290
-280
-270
-260
-250
-240
20
10
0
-10
-20
LATITUDE
LONGITUDE
100CM/SEC

Figure 24

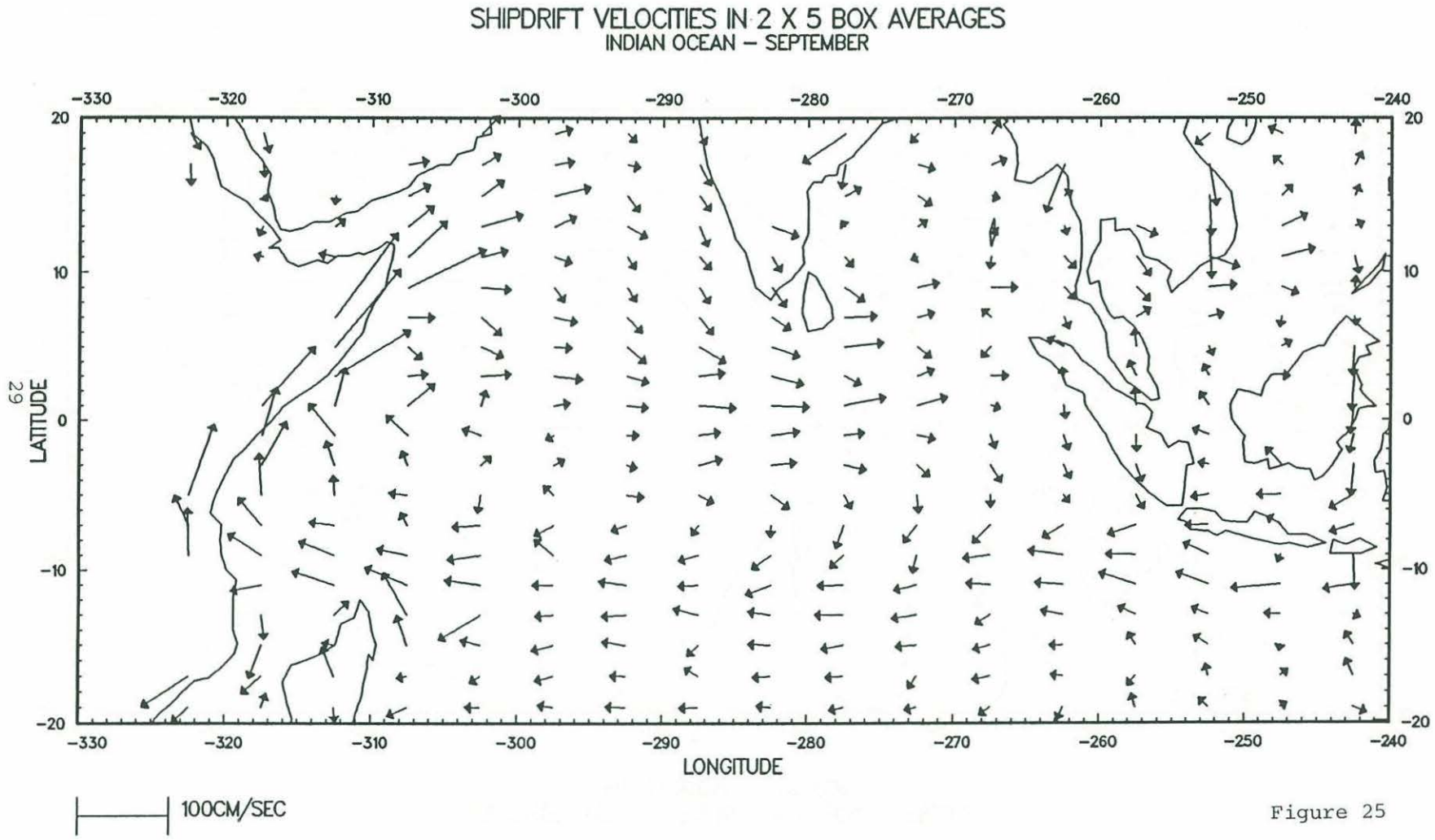

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
INDIAN OCEAN – SEPTEMBER
-330
-320
-310
-300
-290
-280
-270
-260
-250
-240
20
10
0
-10
-20
LATITUDE
LONGITUDE
100CM/SEC

Figure 25

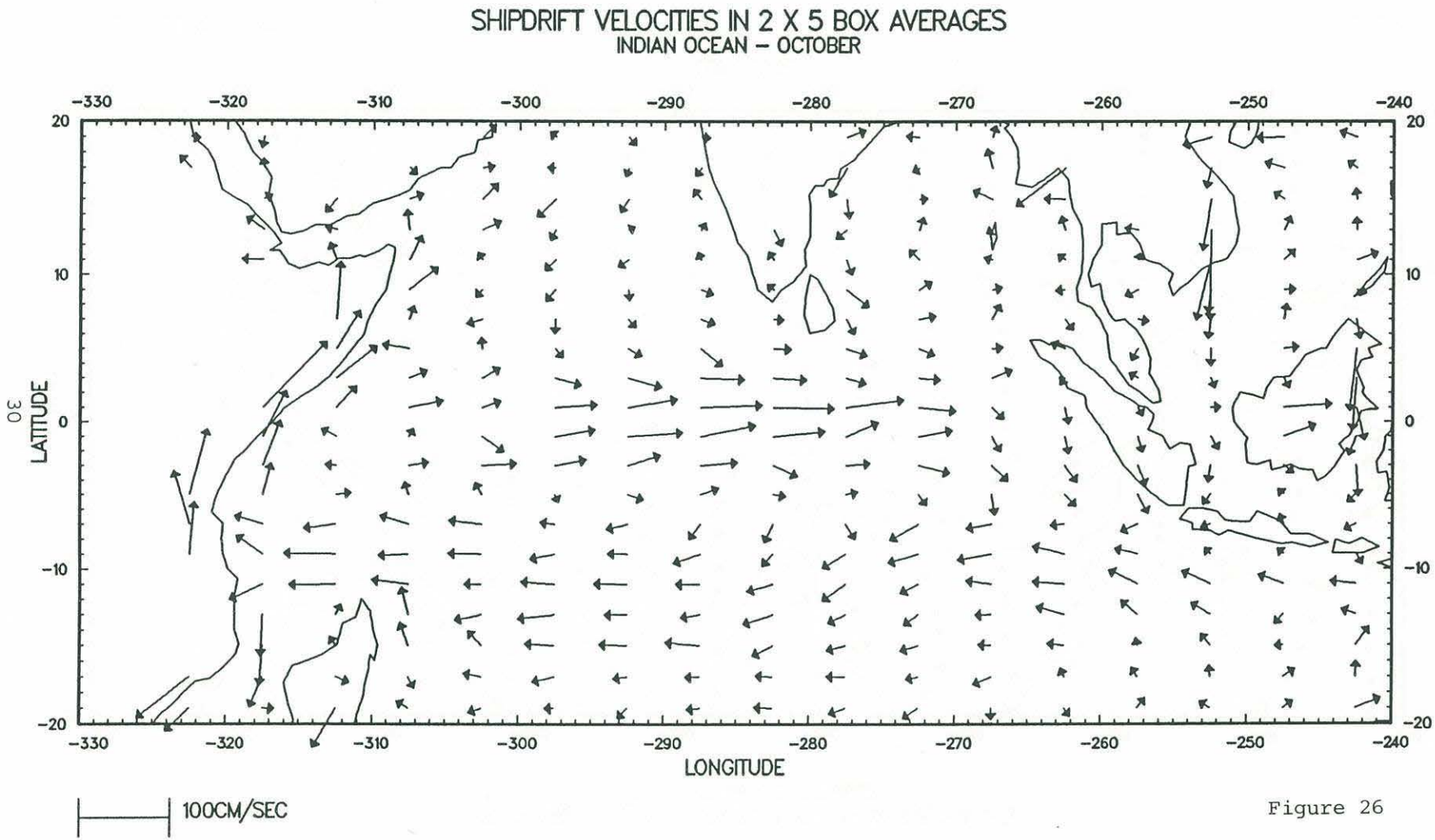

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
INDIAN OCEAN – OCTOBER
-330
-320
-310
-300
-290
-280
-270
-260
-250
-240
20
10
0
-10
-20
LATITUDE
LONGITUDE
100CM/SEC

Figure 26

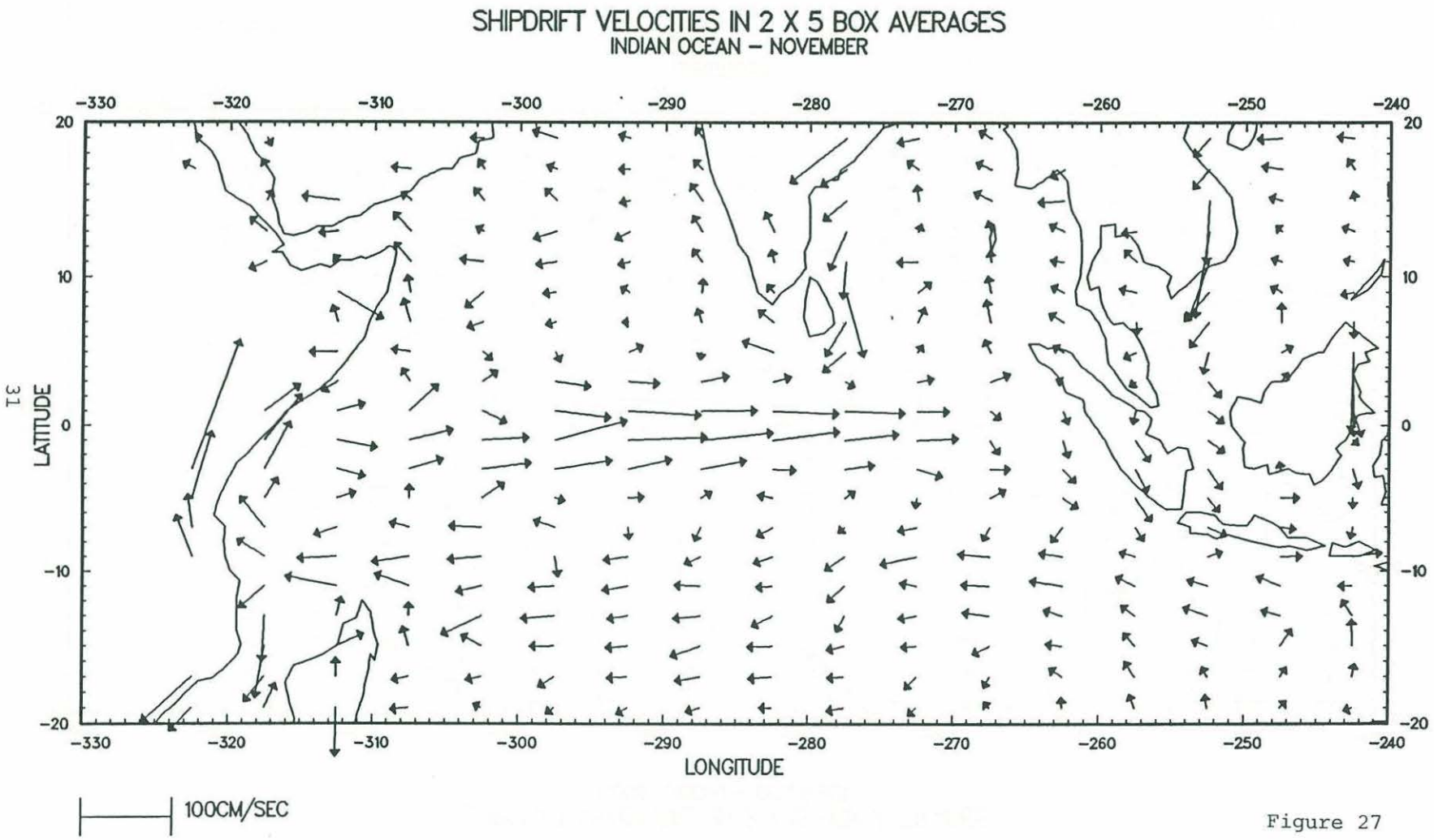

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
INDIAN OCEAN – NOVEMBER
-330
-320
-310
-300
-290
-280
-270
-260
-250
-240
20
10
0
-10
-20
LATITUDE
LONGITUDE
100CM/SEC

Figure 27

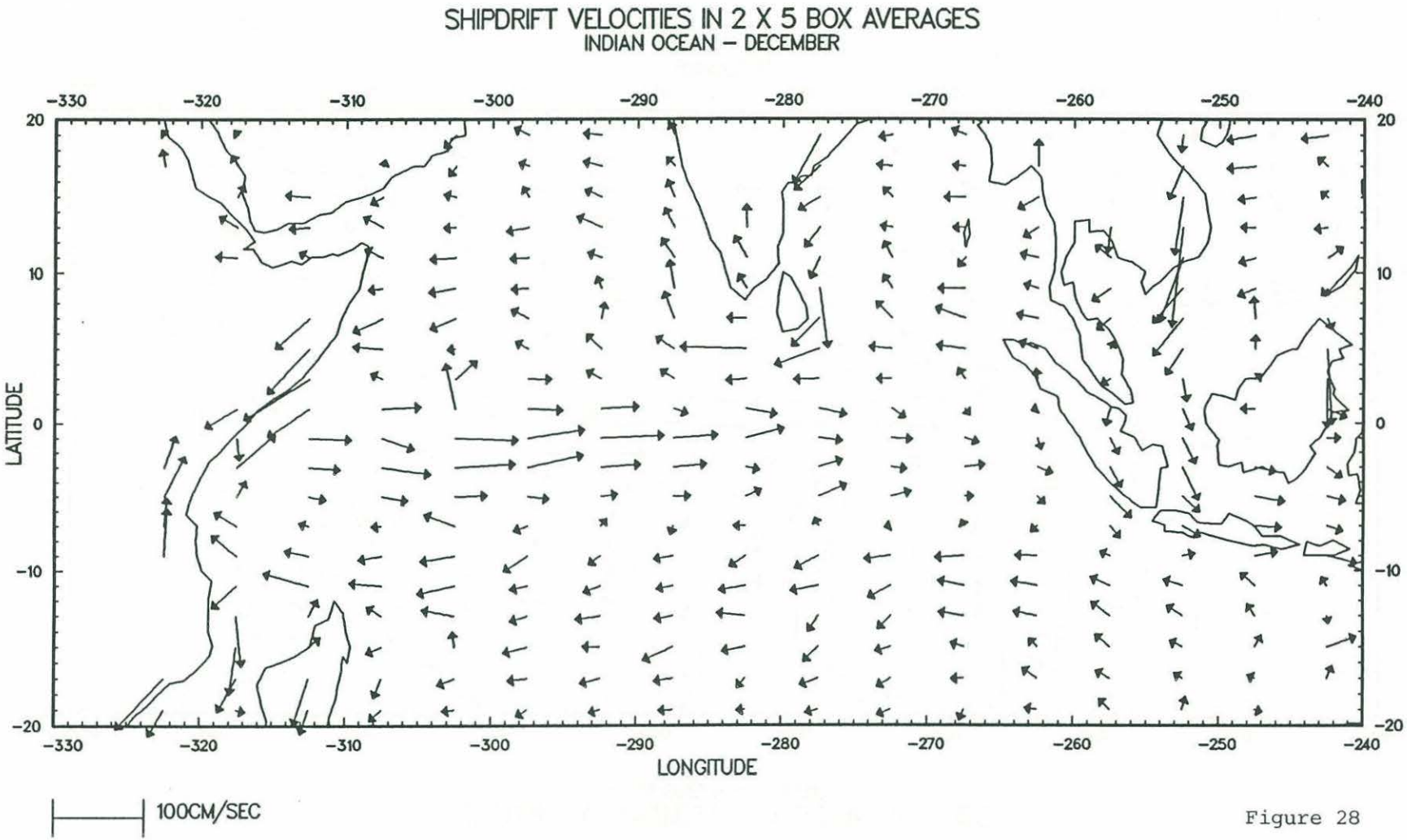

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
INDIAN OCEAN – DECEMBER
-330
-320
-310
-300
-290
-280
-270
-260
-250
-240
20
10
0
-10
-20
LATITUDE
LONGITUDE
100CM/SEC

Figure 28

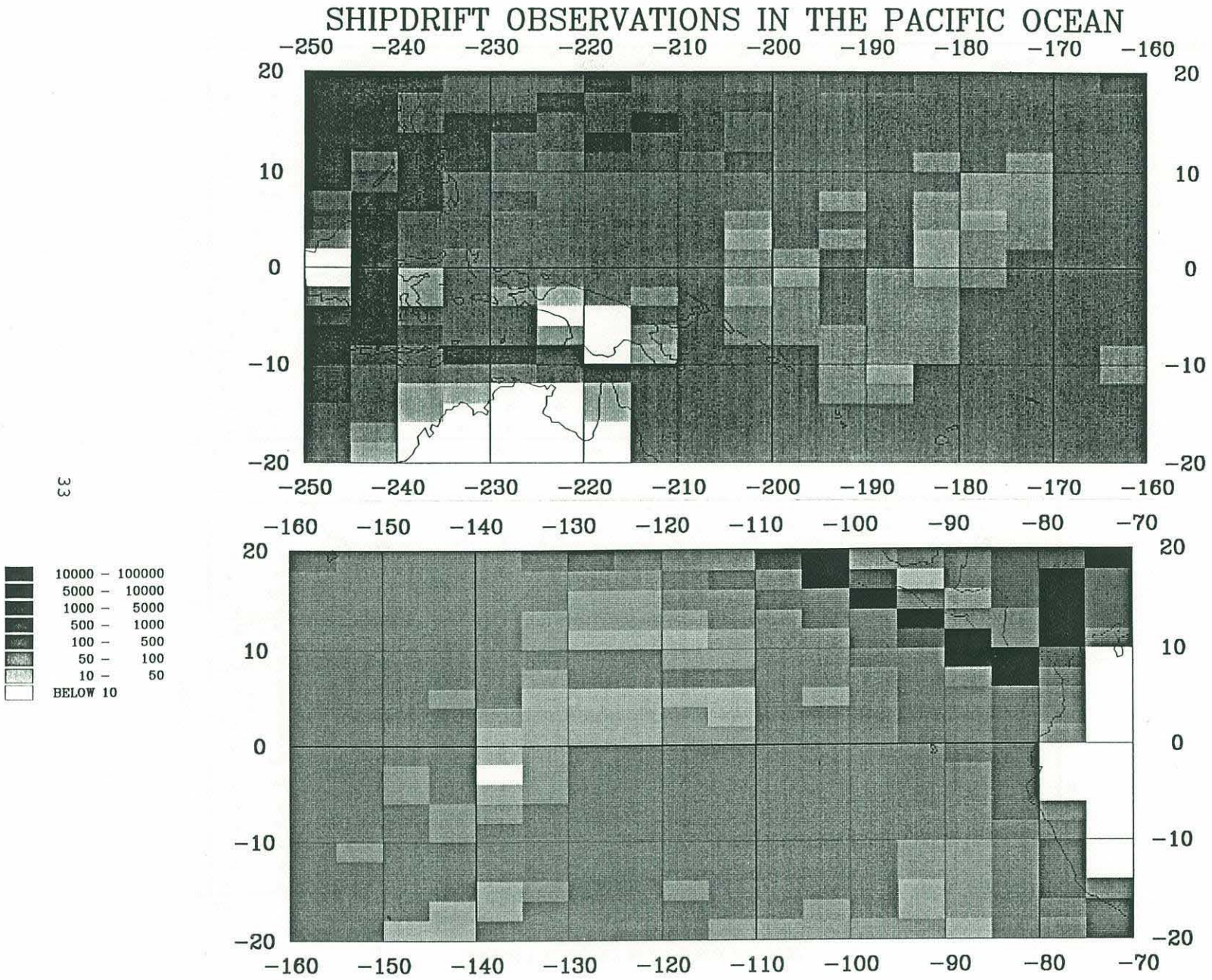

SHIPDRIFT OBSERVATIONS IN THE PACIFIC OCEAN
−250 −240 −230 −220 −210 −200 −190 −180 −170 −160
20
10
0
−10
−20
−160 −150 −140 −130 −120 −110 −100 −90 −80 −70
10000 – 100000
5000 – 10000
1000 – 5000
500 – 1000
100 – 500
50 – 100
10 – 50
BELOW 10

Figure 29

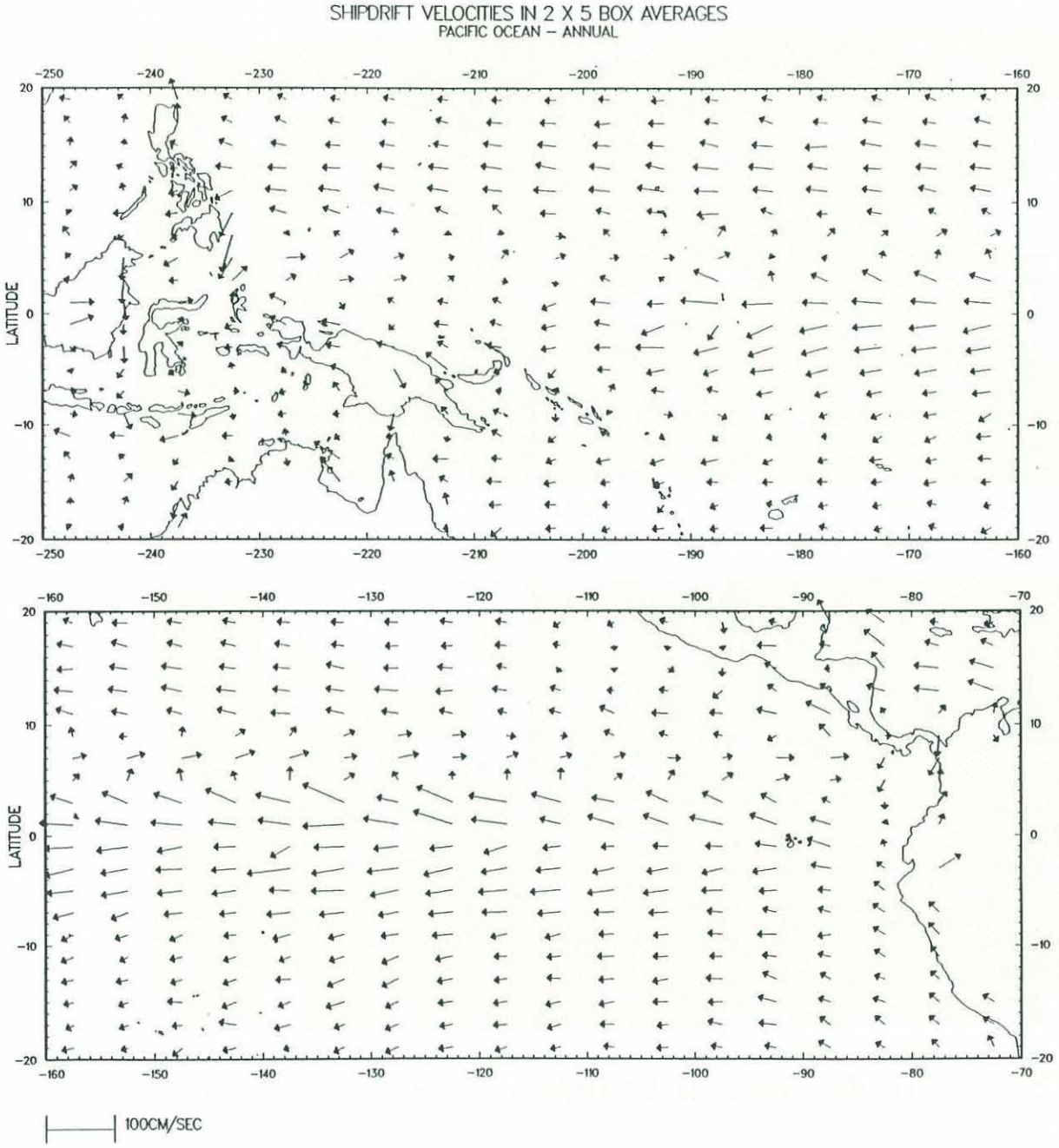

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
PACIFIC OCEAN – ANNUAL
LATITUDE
LATITUDE
100CM/SEC

Figure 30

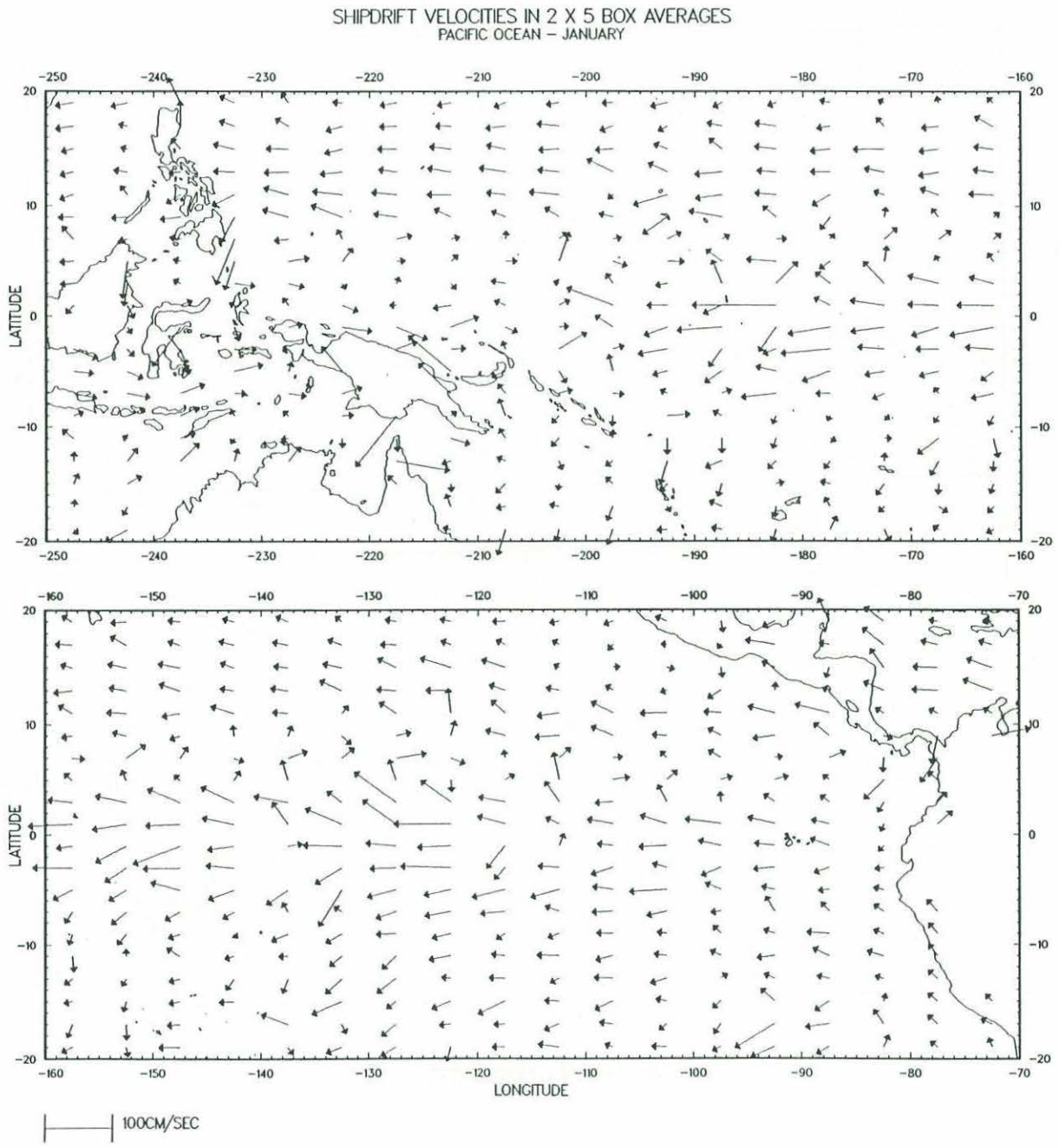

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
PACIFIC OCEAN – JANUARY
LATITUDE
LONGITUDE
100CM/SEC

Figure 31

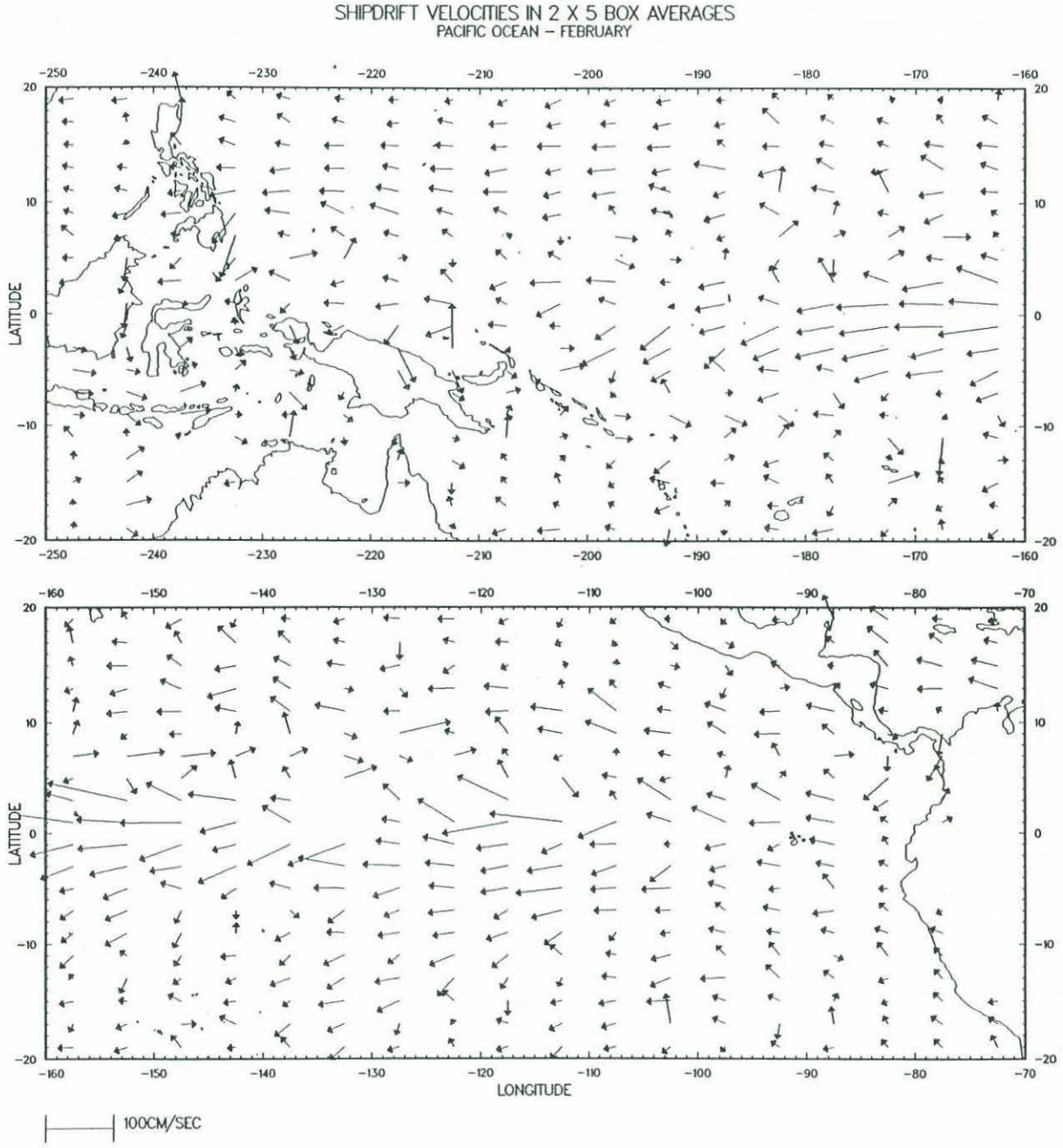

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
PACIFIC OCEAN – FEBRUARY
LATITUDE
LONGITUDE
100CM/SEC

Figure 32

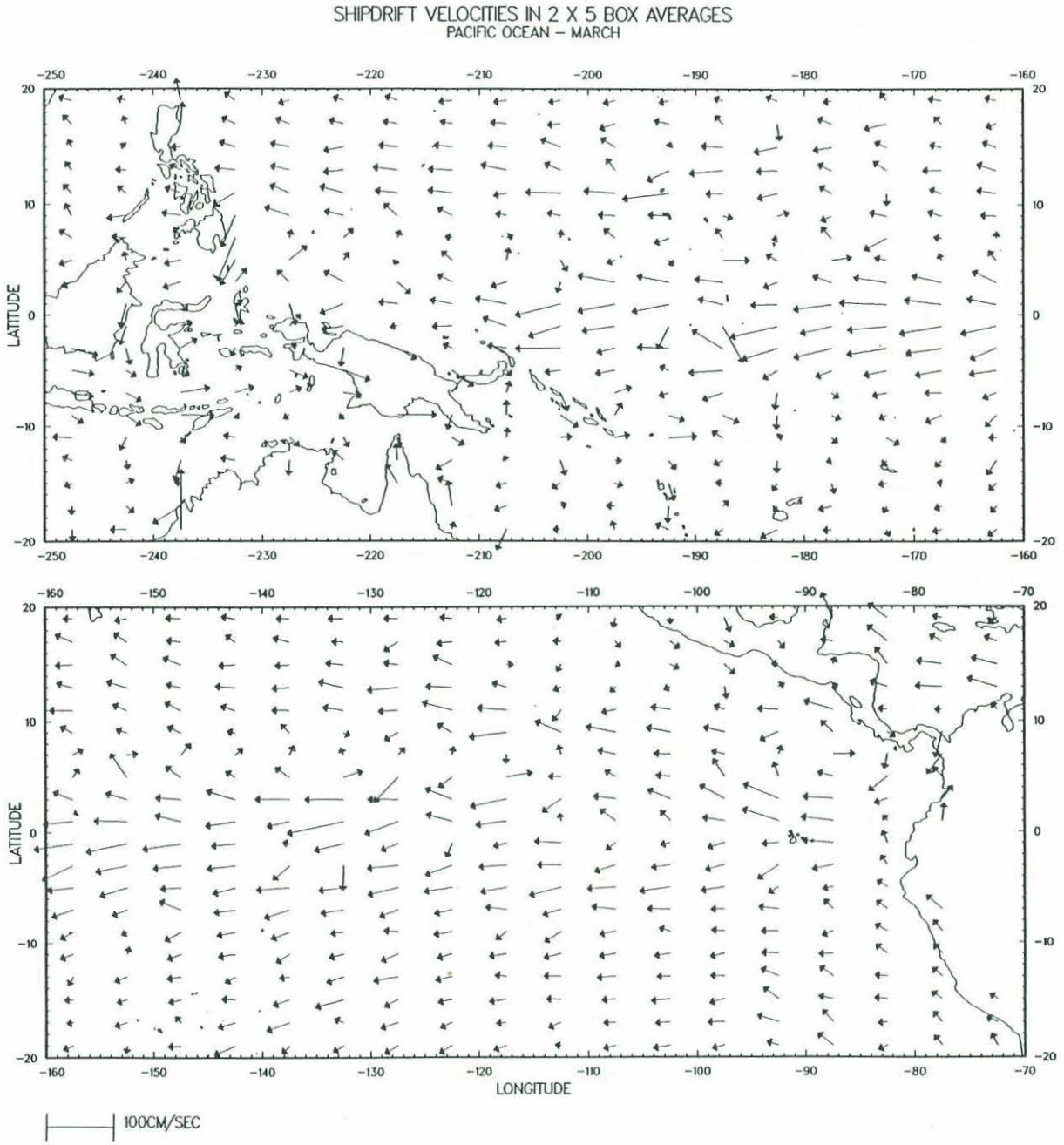

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
PACIFIC OCEAN – MARCH
LATITUDE
LONGITUDE
100CM/SEC

Figure 33

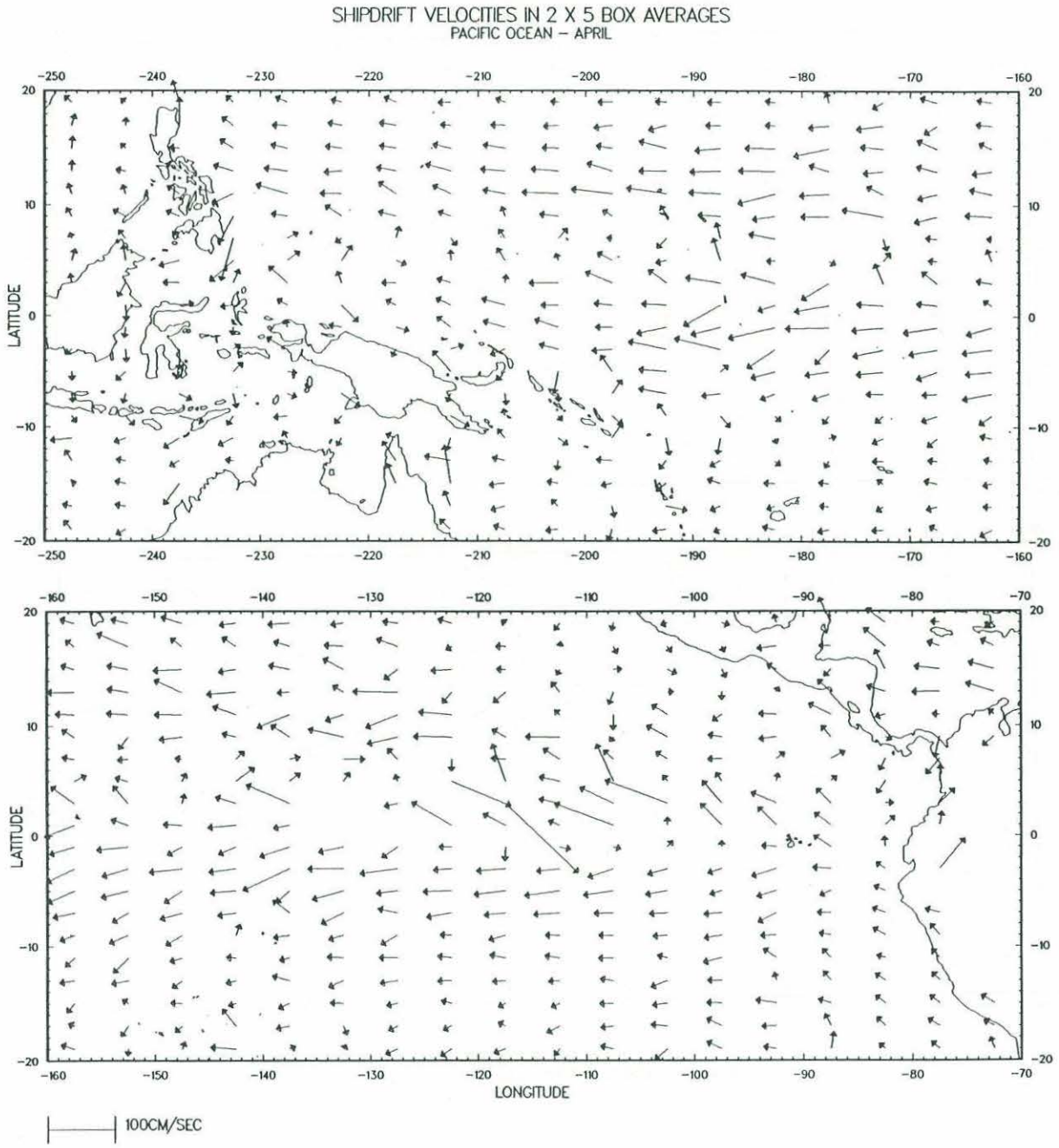

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
PACIFIC OCEAN – APRIL
LATITUDE
LONGITUDE
100CM/SEC

Figure 34

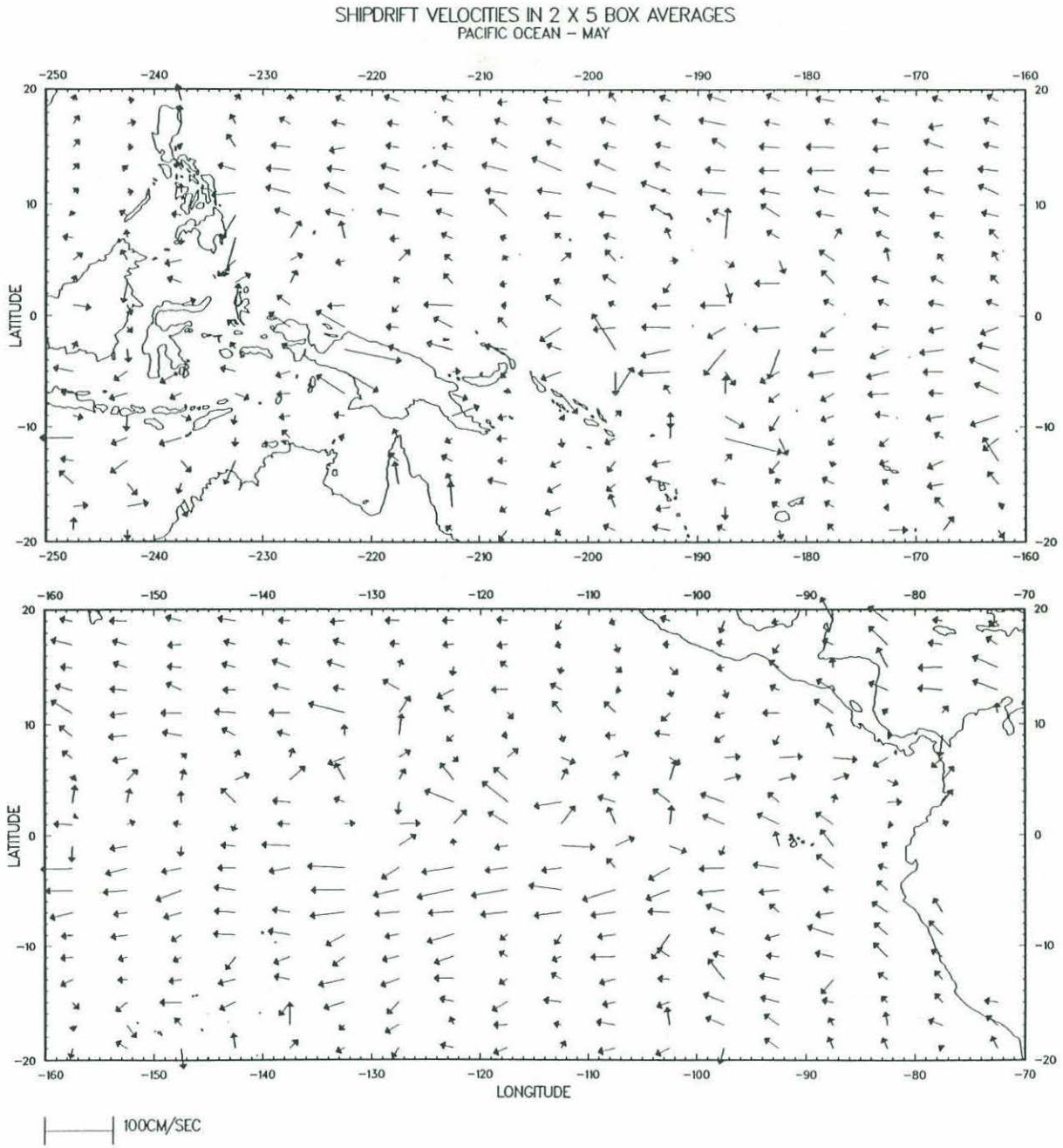

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
PACIFIC OCEAN – MAY
LATITUDE
LONGITUDE
100CM/SEC

Figure 35

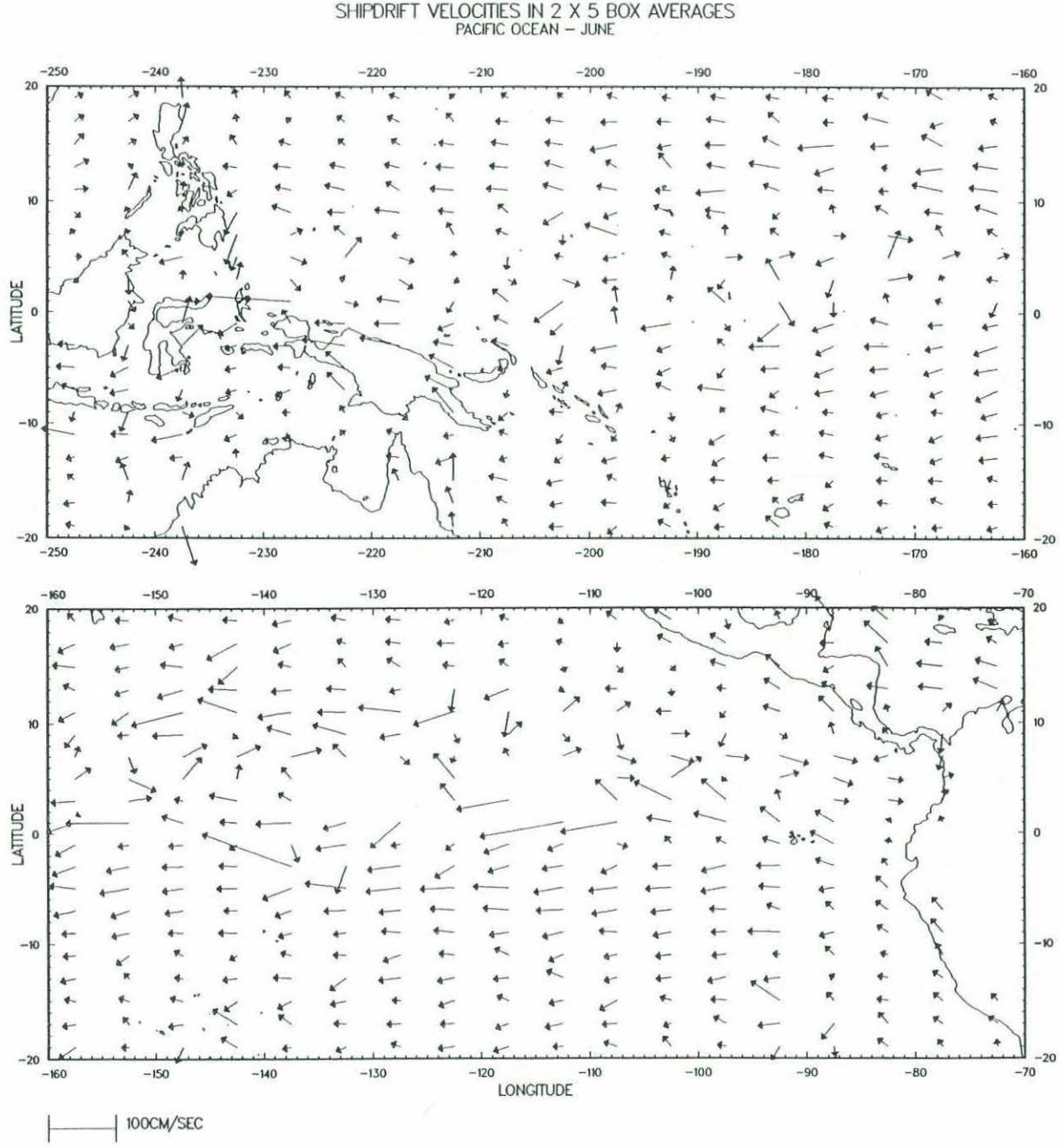

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
PACIFIC OCEAN – JUNE
LATITUDE
LONGITUDE
100CM/SEC

Figure 36

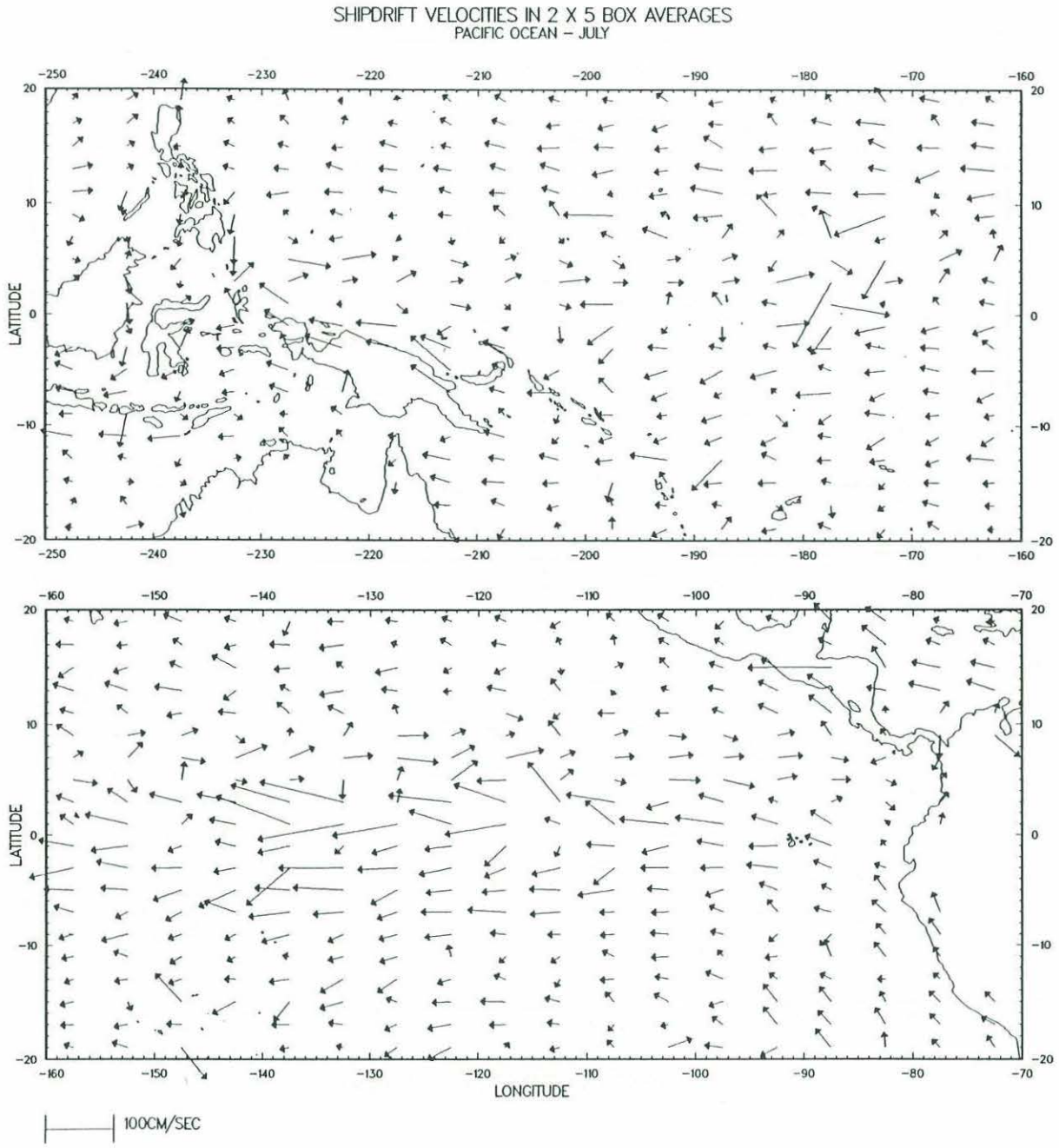

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
PACIFIC OCEAN – JULY
LATITUDE
LONGITUDE
100CM/SEC

Figure 37

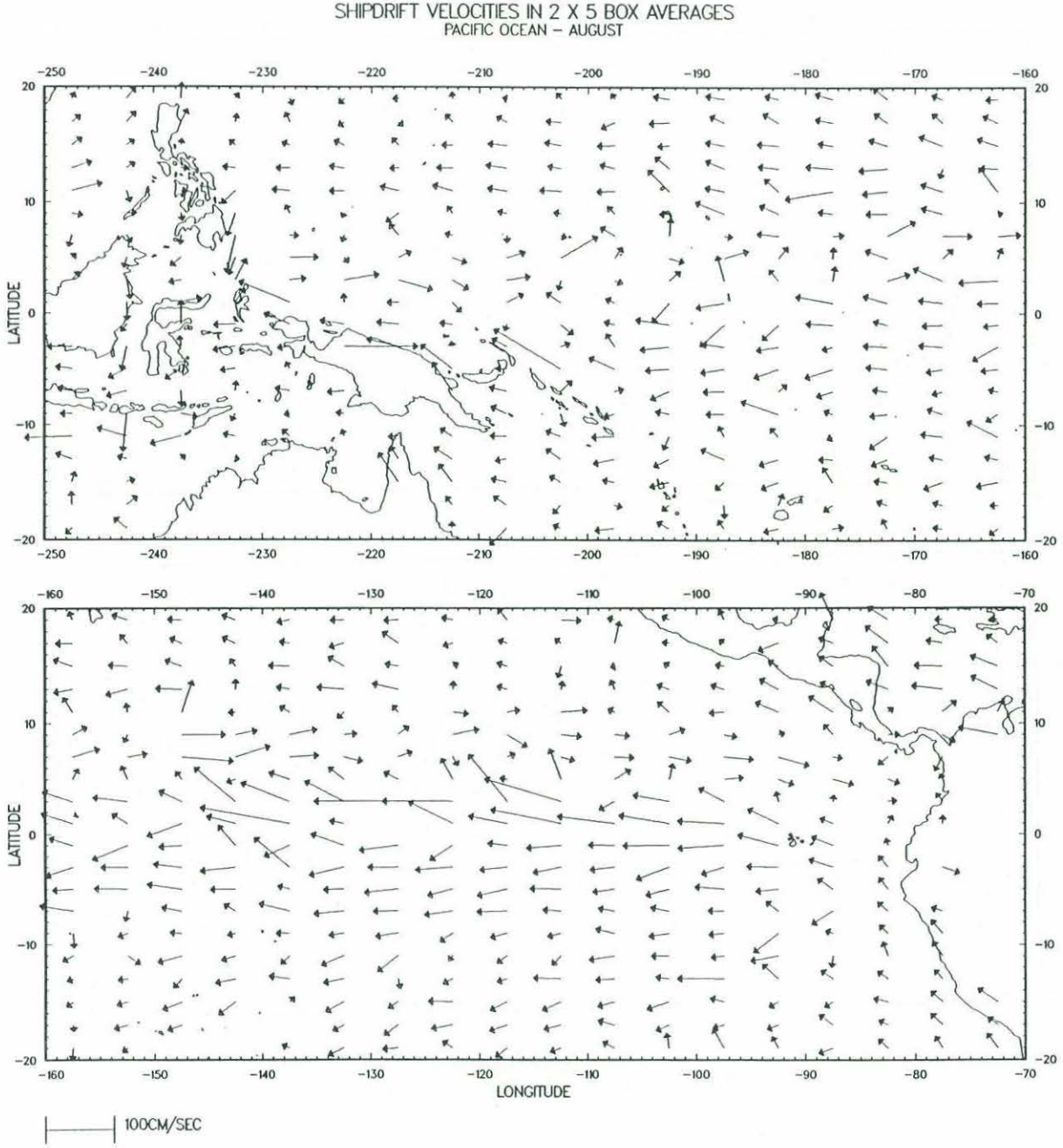

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
PACIFIC OCEAN – AUGUST
LATITUDE
LONGITUDE
100CM/SEC

Figure 38

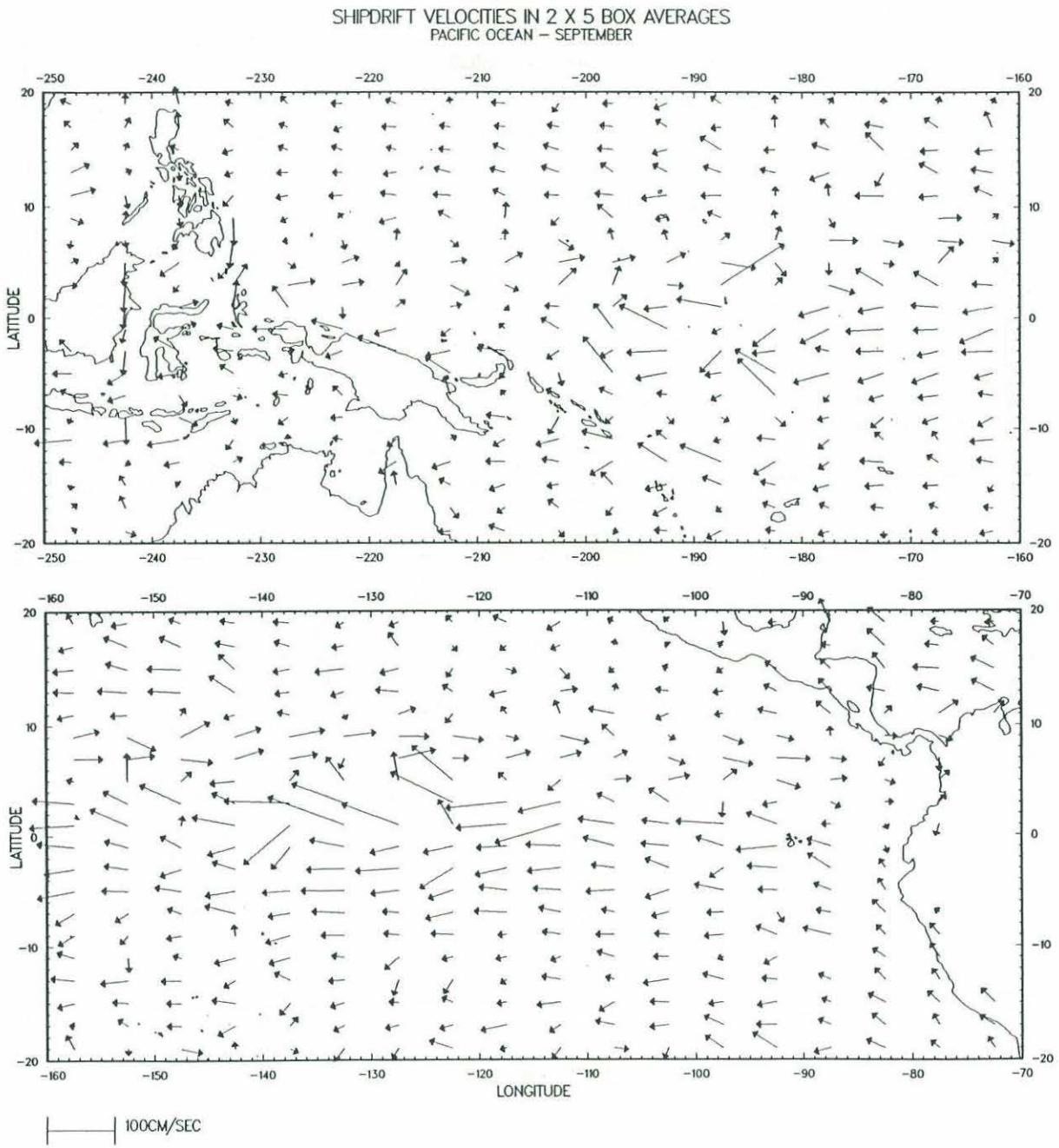

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
PACIFIC OCEAN – SEPTEMBER
LATITUDE
LONGITUDE
100CM/SEC

Figure 39

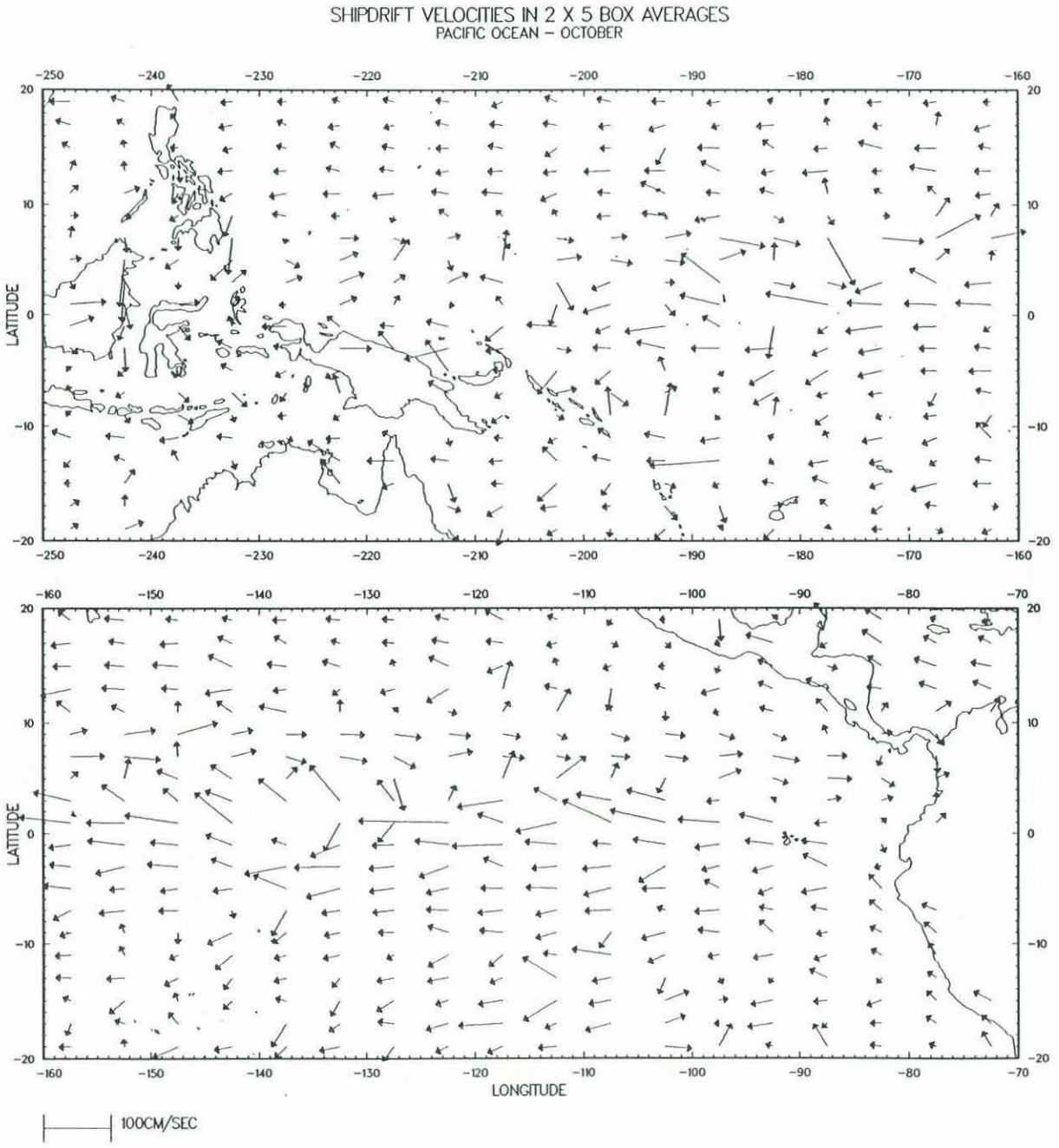

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
PACIFIC OCEAN – OCTOBER
LATITUDE
LONGITUDE
100CM/SEC

Figure 40

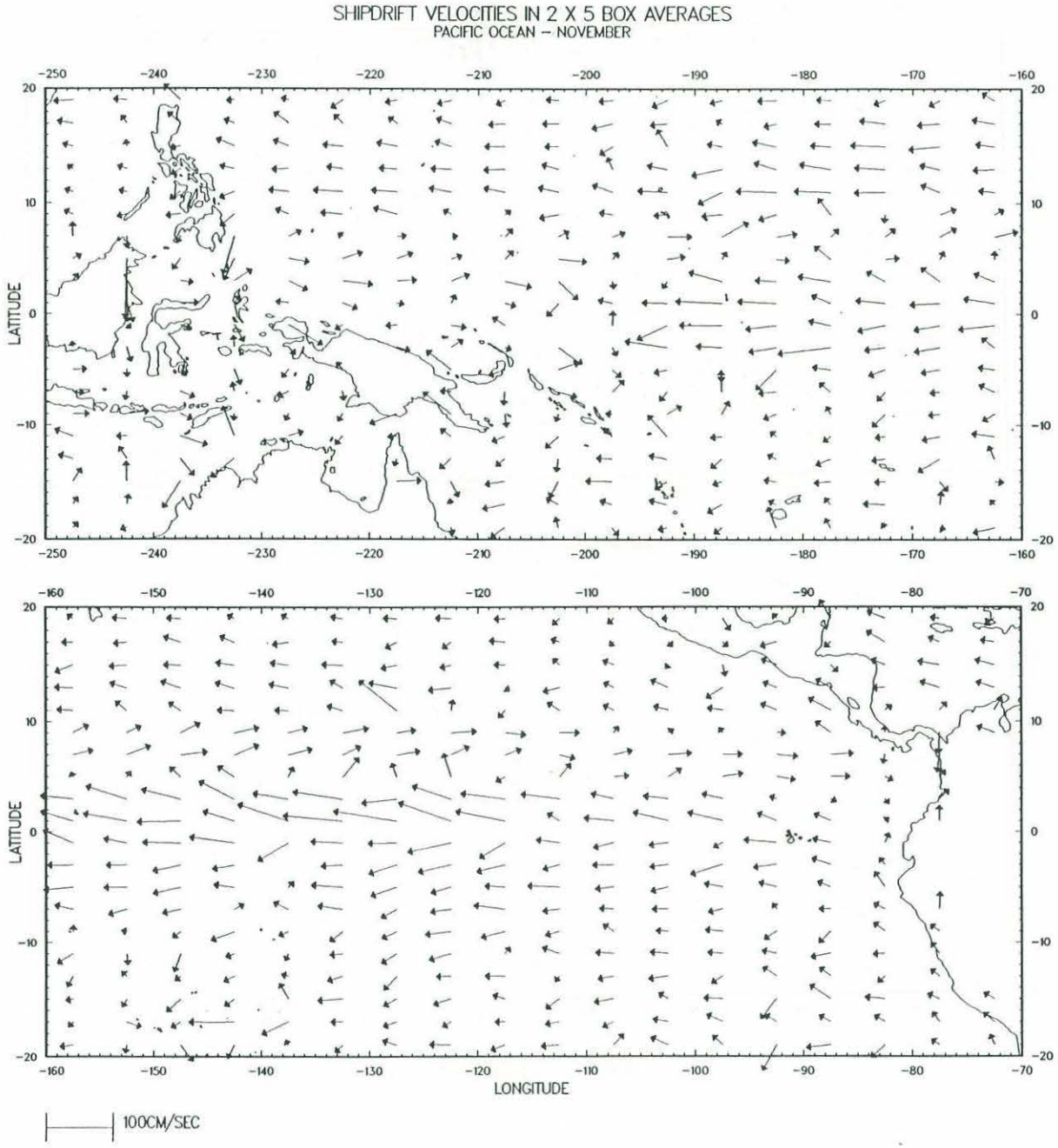

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
PACIFIC OCEAN – NOVEMBER
LATITUDE
LONGITUDE
100CM/SEC

Figure 41

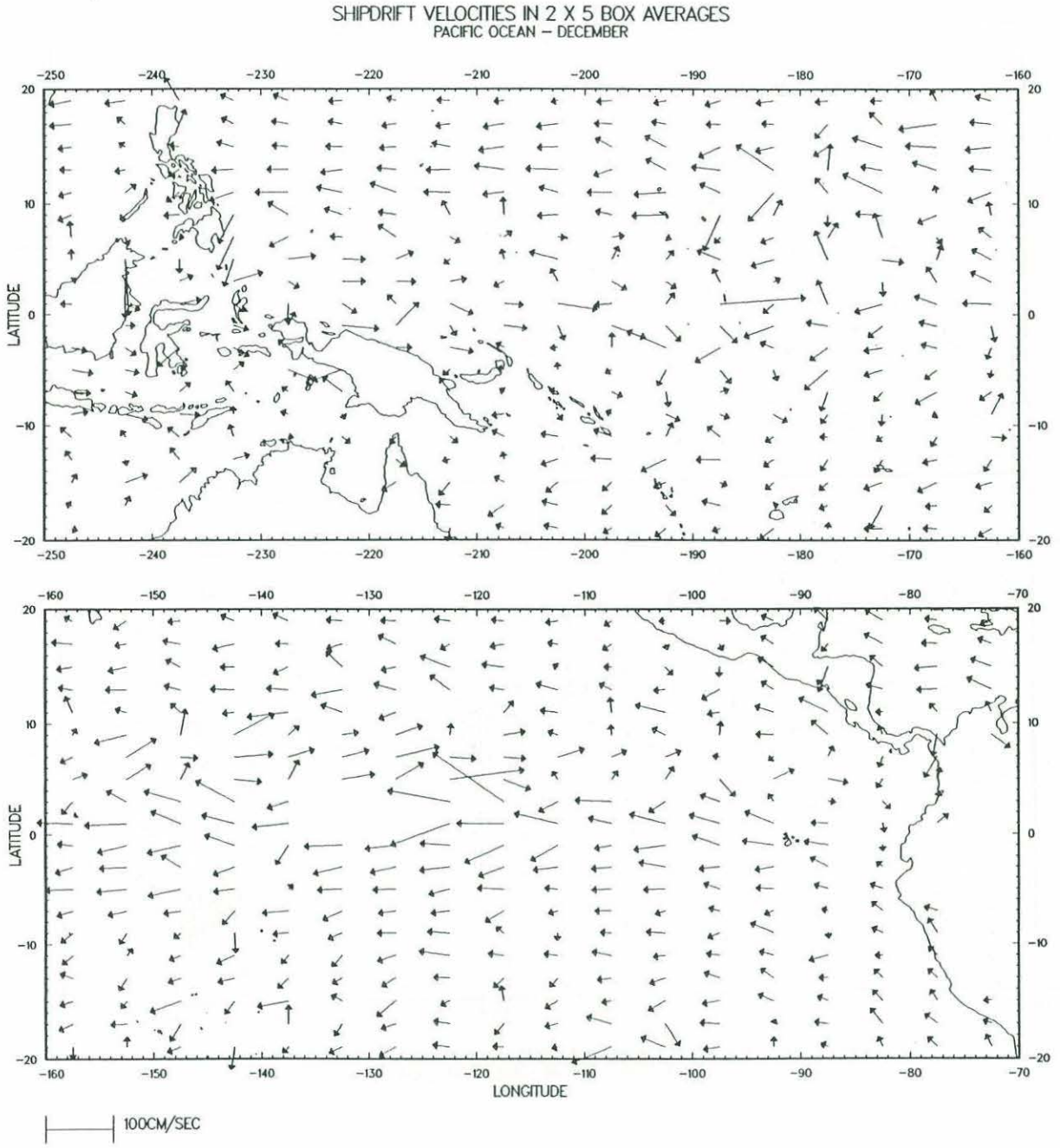

SHIPDRIFT VELOCITIES IN 2 X 5 BOX AVERAGES
PACIFIC OCEAN – DECEMBER
LATITUDE
LONGITUDE
100CM/SEC

Figure 42

W. PACIFIC AND INDONESIAN SEAS SURFACE VELOCITY – SUMMER

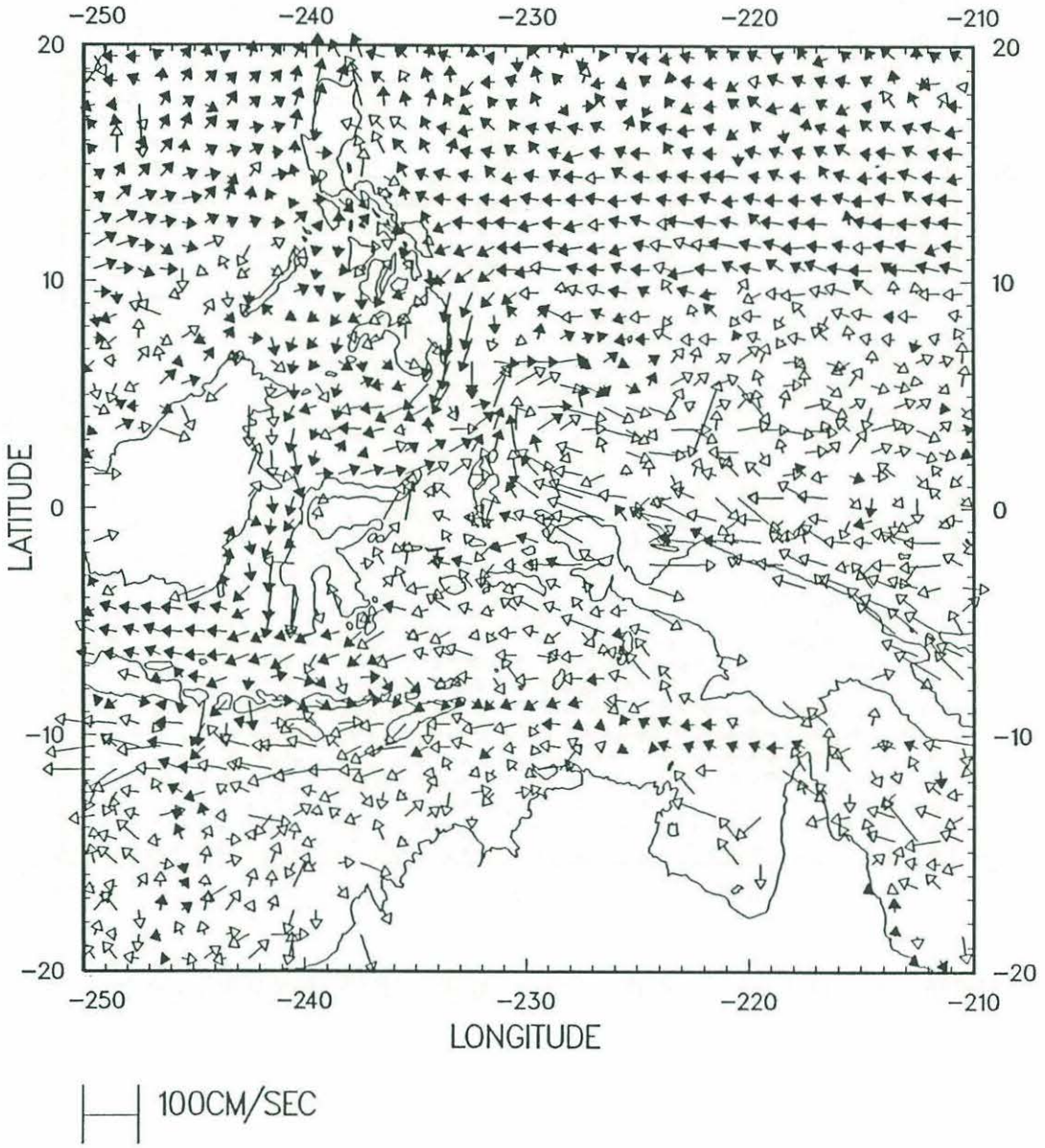


Figure 43

W. PACIFIC AND INDONESIAN SEAS SURFACE VELOCITY – WINTER

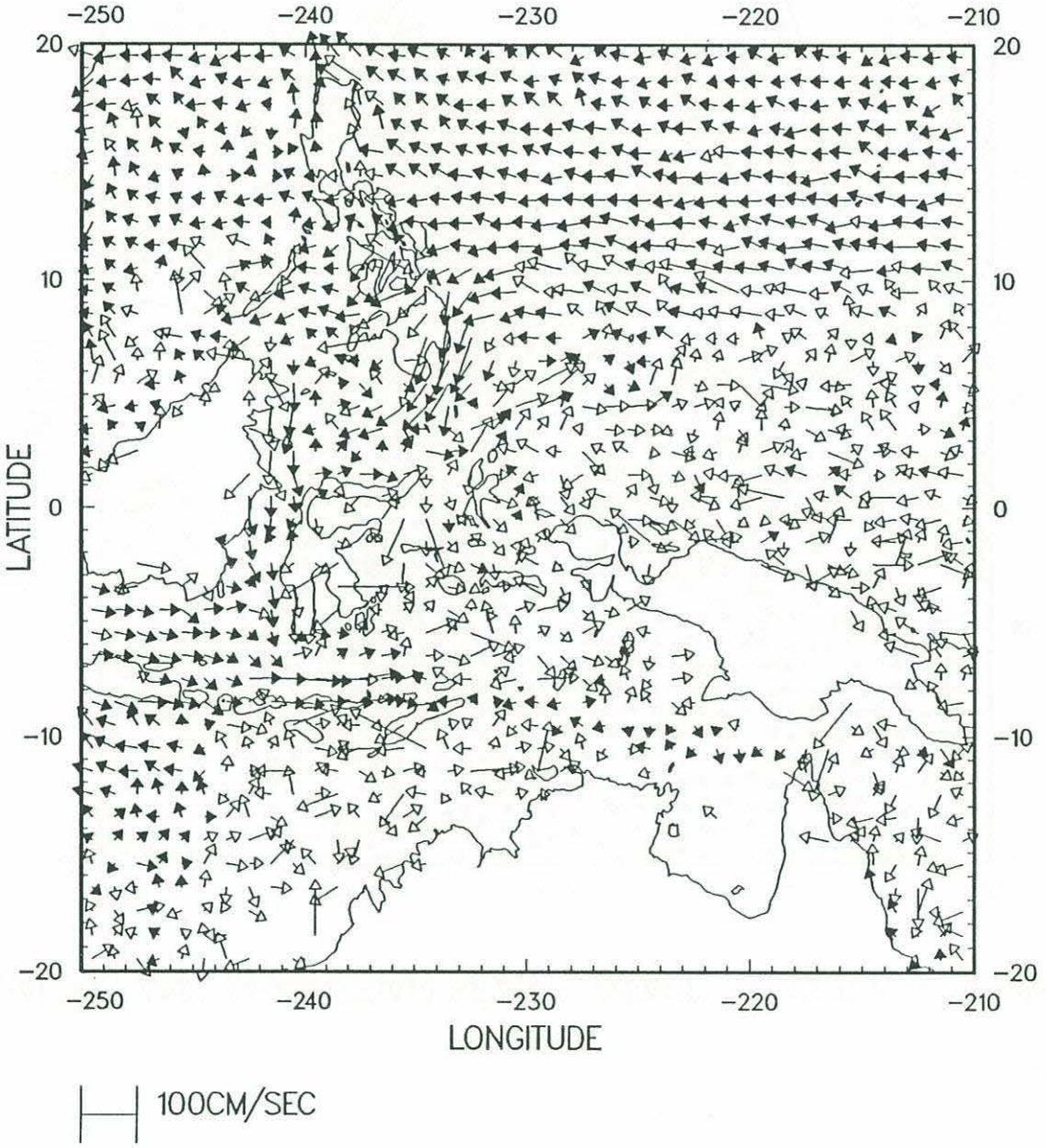


Figure 44

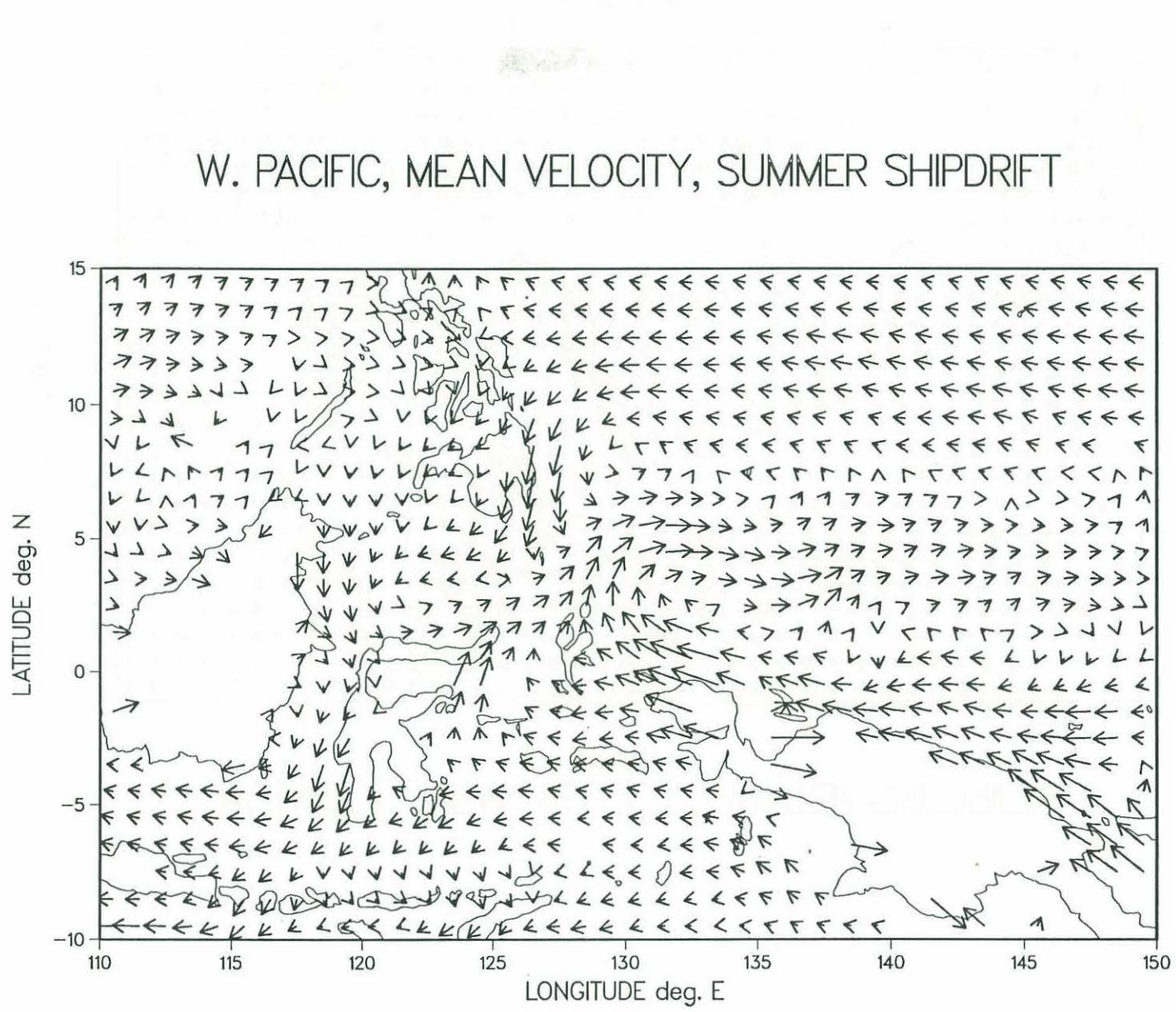

W. PACIFIC, MEAN VELOCITY, SUMMER SHIPDRIFT
LATITUDE deg. N
15
10
5
0
-5
-10
110
115
120
125
130
135
140
145
150
LONGITUDE deg. E
100 cm s^{-1}

Figure 45

W. PACIFIC, MEAN VELOCITY, WINTER SHIPDRIFT

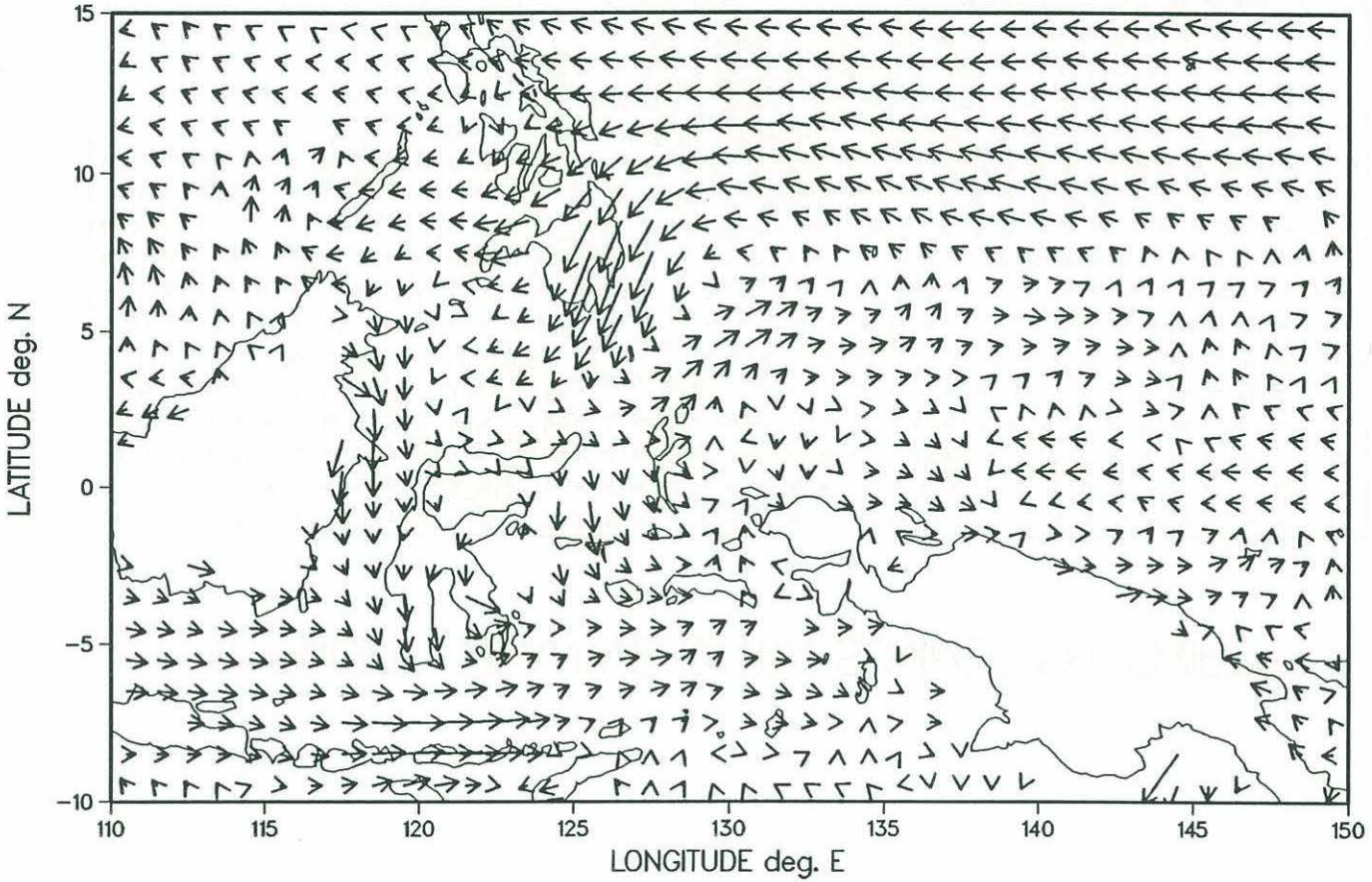


Figure 46

DOCUMENT LIBRARY

August 9, 1988

Distribution List for Technical Report Exchange

Attn: Stella Sanchez-Wade
Documents Section
Scripps Institution of Oceanography
Library, Mail Code C-075C
La Jolla, CA 92093

Hancock Library of Biology &
Oceanography
Alan Hancock Laboratory
University of Southern California
University Park
Los Angeles, CA 90089-0371

Gifts & Exchanges
Library
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, NS, B2Y 4A2, CANADA

Office of the International
Ice Patrol
c/o Coast Guard R & D Center
Avery Point
Groton, CT 06340

Library
Physical Oceanographic Laboratory
Nova University
8000 N. Ocean Drive
Dania, FL 33304

NOAA/EDIS Miami Library Center
4301 Rickenbacker Causeway
Miami, FL 33149

Library
Skidaway Institute of Oceanography
P.O. Box 13687
Savannah, GA 31416

Institute of Geophysics
University of Hawaii
Library Room 252
2525 Correa Road
Honolulu, HI 96822

Library
Chesapeake Bay Institute
4800 Atwell Road
Shady Side, MD 20876

MIT Libraries
Serial Journal Room 14E-210
Cambridge, MA 02139

Director, Ralph M. Parsons Laboratory
Room 48-311
MIT
Cambridge, MA 02139

Marine Resources Information Center
Building E38-320
MIT
Cambridge, MA 02139

Library
Lamont-Doherty Geological
Observatory
Colombia University
Palisades, NY 10964

Library
Serials Department
Oregon State University
Corvallis, OR 97331

Pell Marine Science Library
University of Rhode Island
Narragansett Bay Campus
Narragansett, RI 02882

Working Collection
Texas A&M University
Dept. of Oceanography
College Station, TX 77843

Library
Virginia Institute of Marine Science
Gloucester Point, VA 23062

Fisheries-Oceanography Library
151 Oceanography Teaching Bldg.
University of Washington
Seattle, WA 98195

Library
R.S.M.A.S.
University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149

Maury Oceanographic Library
Naval Oceanographic Office
Bay St. Louis
NSTL, MS 39522-5001

Marine Sciences Collection
Mayaguez Campus Library
University of Puerto Rico
Mayagues, Puerto Rico 00708

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. WHOI-89-9	2.	3. Recipient's Accession No.

4. Title and Subtitle

Surface Velocity in the Equatorial Oceans (20N–20S) Calculated from Historical Ship Drifts

5. Report Date April 1989

6.

7. Author(s)
Philip L. Richardson, Theresa K. McKee

8. Performing Organization Rept. No. WHOI-89-9

9. Performing Organization Name and Address

The Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)
(G) OCE 87-16509

12. Sponsoring Organization Name and Address
The National Science Foundation

13. Type of Report & Period Covered
Technical Report

14.

15. Supplementary Notes

This report should be cited as: Woods Hole Oceanog. Inst. Tech. Rept., WHOI-89-9.

16. Abstract (Limit: 200 words)

Ship drift velocity observations were used to calculate and plot monthly mean and yearly mean velocities in 2° latitude by 5° longitude boxes for the Atlantic, Pacific, and Indian Oceans. The vector maps shown here provide a visualization of the mean and seasonally varying currents.

17. Document Analysis a. Descriptors

1. surface velocity
2. ship drifts
3. equatorial currents

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Approved for publication; distribution unlimited.	UNCLASSIFIED	50
	20. Security Class (This Page)	22. Price

(See ANSI-Z39.18) *See Instructions on Reverse*

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce